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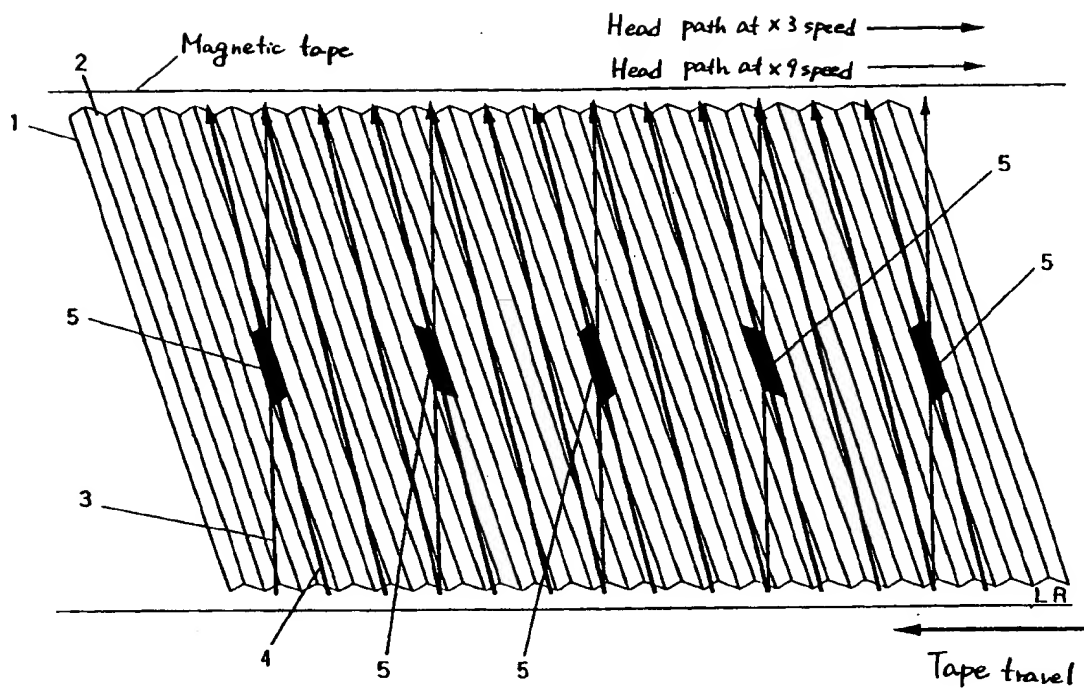
(54) **Signal recording and reproducing apparatus.**

(57) The disclosed apparatus for recording and reproducing data includes: a recording medium traveling section for making a recording medium to travel in a first direction; a rotating drum which rotates with an angle with respect to the first direction, the rotating drum having a head used for recording and reproducing the data; a recording section for record-

ing first data of the data onto a first portion of the recording medium, the first portion being commonly passed by the head at three or more predetermined speeds; and a reproducing section for reproducing the first data which is recorded at least on the first portion of the recording medium at each of the three or more predetermined speeds.

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Fig. 1



## **BACKGROUND OF THE INVENTION**

### **1. Field of the Invention:**

The present invention relates to a signal recording and reproducing apparatus of helical scan type for recording and reproducing signals by using a rotation head. More particularly, the present invention relates to a signal recording and reproducing apparatus capable of positively reproducing signals recorded at predetermined positions of a recording medium even when the reproduction is to be performed at a speed which is different from the speed at which the signals were recorded.

### **2. Description of the Related Art:**

In a signal recording and reproducing apparatus of helical scan type, signals are recorded on or reproduced from a tape-like recording medium such as a magnetic tape by using rotation heads. A prior art signal recording and reproducing apparatus of helical scan type has a problem in that, when the recording medium is made to travel at a high speed in reproduction, it is very difficult to obtain data required for the high-speed reproduction. This is because the path of the head relative to the recorded tracks varies depending on the traveling speed of the recording medium. As a conventional solution to the problem, for example shown in Japanese Laid-Open Patent Publication No. 2-94071, the high-speed reproduction speed is limited to only one specific speed, and data required for the high-speed reproduction is recorded at a position corresponding to the head path at that specific speed.

In such a prior art signal recording and reproducing apparatus, the data for high-speed reproduction is located at a position corresponding to the head path at the specific high-speed reproduction speed. Accordingly, the reproduction can basically be performed only at that specific high speed, in addition to the normal reproduction speed. In other words, it is impossible to reproduce data for high-speed reproduction at various high speeds.

Moreover, when an image is to be reproduced at various reproduction speeds by using the above conventional solution, it is necessary to record data for high-speed reproduction at positions corresponding to the head paths at the various reproduction speeds. This causes a problem of an increase in the recorded bit rate.

## **SUMMARY OF THE INVENTION**

The apparatus for recording and reproducing data of this invention includes: recording medium

traveling means for making a recording medium to travel in a first direction; rotating drum means which rotates with an angle with respect to the first direction, the rotating drum means having a head used for recording and reproducing the data; recording means for recording first data of the data onto a first portion of the recording medium, the first portion being commonly passed by the head at three or more predetermined speeds; and reproducing means for reproducing the first data which is recorded at least on the first portion of the recording medium at each of the three or more predetermined speeds.

In one embodiment of the invention, the first portion is part of tracks which are formed on the recording medium, and the tracks including the first portions are located on the recording medium at a predetermined first pitch along the first direction.

In another embodiment of the invention, the first portion is located in the vicinity of the center of a track formed on the recording medium.

In another embodiment of the invention, the data is a video data, and the first data is at least part of video data of one frame corresponding to a screen selected at a predetermined rate among a plurality of screens, or at least part of video data of one field corresponding to the selected screen.

In another embodiment of the invention, the data is video data, and the first data includes a component which coarsely constitutes an image.

In another embodiment of the invention, the data is video data, and the first data includes video data to which at least an orthogonal base transform and quantization are performed.

In another embodiment of the invention, the orthogonal base transform is a discrete cosine transform or an Hadamard transform.

In another embodiment of the invention, the first data includes at least an upper bit of a DC component obtained by the orthogonal base transform.

In another embodiment of the invention, the data is video data, the recording means includes at least one of: first redundant component suppressing means for suppressing a visual redundant component or a statistic redundant component of the video data, only by using video data of one frame or video data of one field; and second redundant component suppressing means for suppressing a visual redundant component or a statistic redundant component of the video data, only by using video data of plural frames or video data of plural fields, and the reproducing means includes at least one of: first recovering means for recovering the suppressed video data by the first redundant component suppressing means to the original video data; and second recovering means for recovering the suppressed video data by the second redundant

dant component suppressing means to the original video data.

In another embodiment of the invention, the data is video data having a suppressed visual redundant component or a suppressed statistic redundant component, and the first data includes at least part of the suppressed video data of one frame or at least part of the suppressed video data of one field.

In another embodiment of the invention, the first data of the data and the remaining data of the data are input into the recording means separately from each other.

In another embodiment of the invention, the recording means includes means for adding a contents identification code for identifying the contents of the data to at least one of the first data of the data and the remaining data of the data, and the reproducing means includes means for identifying the contents of the data based on the contents identification code.

In another embodiment of the invention, the first data includes a track identification code for identifying a type of track formed on the recording medium.

In another embodiment of the invention, the recording means includes at least one of: means for adding, to the first data of the data, a first position identification code indicating the position of the first data on a track; means for adding, to second data which is recorded on the track on which the first data is recorded in a forward portion thereof with respect to the first data, a second position identification code indicating the position of the second data on the track; and means for adding, to third data which is recorded on the track on which the first data is recorded in a backward portion thereof with respect to the first data, a third position identification code indicating the position of the third data on the track.

In another embodiment of the invention, the reproducing means includes: detection means for detecting a relative positional relationship between the head and the first portion, based on at least one of the first, second, and third position identification codes recorded on the track; and adjusting means for adjusting the relative positional relationship between the head and the first portion so that the head passes the first portion, on the basis of the detected relative positional relationship.

In another embodiment of the invention, the adjusting means adjusts the relative positional relationship between the head and the first portion, by variably setting at least one of a traveling speed of the recording medium, a rotation speed of the rotating drum means and a position of the head mounted on the rotating drum means.

According to another aspect of the invention, the apparatus for recording and reproducing data includes: recording medium traveling means for making a recording medium to travel in a first direction; rotating drum means which rotates with an angle with respect to the first direction, the rotating drum means having a head used for recording and reproducing the data; recording means for recording first data of the data onto a first portion of the recording medium, the first portion being commonly passed by the head at three or more predetermined speeds and for recording second data of the data which is different from the first data onto a second portion of the recording medium, the second portion being passed by the head at at least one of the three or more predetermined speeds; and reproducing means for reproducing the first data which is recorded at least on the first portion of the recording medium at each of the three or more predetermined speeds.

In one embodiment of the invention, the first portion is part of tracks which are formed on the recording medium, and the tracks including the first portions are located on the recording medium at a predetermined first pitch along the first direction, and wherein the second portion is part of tracks which are formed between the tracks each including the first portion, and the tracks each including the second portion and the tracks each including the first portion are located on the recording medium at a predetermined second pitch along the first direction.

In another embodiment of the invention, the second portion is part of tracks each including the first portion, the second portion being positioned differently from the first portion.

In another embodiment of the invention, the first and second portions are located in the vicinity of the center of a track formed on the recording medium.

In another embodiment of the invention, the data is video data, the first data includes a component which coarsely constitutes an image, and the second data includes a component which constitutes the image as coarsely as that in the first data or a component which constitutes the image at a higher definition degree than that in the first data.

In another embodiment of the invention, the data is video data, and the first data and the second data include video data to which at least an orthogonal base transform and quantization are performed.

In another embodiment of the invention, the orthogonal base transform is a discrete cosine transform or an Hadamard transform.

In another embodiment of the invention, the first data includes at least upper bits of a direct current component which is obtained by the or-

thogonal base transform, and the second data includes at least a component which is equivalent to that in the first data or upper bits of an alternate current component which is closest to the direct current next to the direct current component in the first data.

According to another aspect of the invention, the apparatus for recording and reproducing video data includes: recording medium traveling means for making a recording medium to travel in a first direction; rotating drum means which rotates with an angle with respect to the first direction, the rotating drum means having a head used for recording and reproducing the data; means for dividing video data constituting one screen into a plurality of blocks; means for performing a variable length coding for each of the plurality of blocks, to suppress the statistic redundancy of the video data; means for assigning a first priority based on a position of a block on the screen and a second priority based on the importance of components included in the block to the data having fixed length or variable length in the variable-length coded block; means for determining, from the data having fixed length or variable length in the variable-length coded block, first data which is to be reproduced at three or more predetermined speeds, based on the first priority and the second priority; means for rearranging the data having fixed length or variable length in the variable-length coded block in order for the determined first data to be recorded onto a first portion of the recording medium, the first portion being commonly passed by the head at the three or more predetermined speeds; recording means for recording the rearranged data onto the recording medium; and reproducing means for reproducing the first data which is recorded at least on the first portion of the recording medium at each of the three or more predetermined speeds.

In one embodiment of the invention, the first priority is higher as the position of the block is closer to the center of the screen.

In another embodiment of the invention, the second priority is higher as components among the components included in the block constitute an image more coarsely.

In another embodiment of the invention, the first data is determined based on a first rule by which the first priority is used from the highest one to the lowest one, a second rule by which the second priority is used from the highest one to the lowest one, and a third rule by which the second priority is used in preference to the first priority.

In another embodiment of the invention, the recording means includes subsampling means for performing subsampling by each block at least for direct current components of the data having fixed

length or variable length in the variable-length coded block, and for classifying at least the direct current components into a first group and a second group, and wherein the data having fixed length or variable length in the variable-length coded block is rearranged depending on whether the data having fixed length or variable length in the variable-length coded block belongs to the first group or to the second group.

In another embodiment of the invention, the subsampling means extracts alternate blocks in the horizontal direction and in the vertical direction of the screen, whereby at least the direct current components are classified into the first group and the second group.

In another embodiment of the invention, the subsampling means performs the subsampling by each block only for the direct current components of the data having fixed length or variable length in the variable-length coded block.

In another embodiment of the invention, at least direct current components of the data are recorded as data having fixed length.

In another embodiment of the invention, the reproducing means includes interpolation means for, when at least part of data included in one of the first and the second groups is lost in the reproduction, interpolating at least a direct current component of the lost data by using data included in the other group.

In another embodiment of the invention, the interpolation means interpolates at least a direct current component of the lost data by selectively using the data of image blocks which is positioned in the vicinity of an image block corresponding to the lost data among the data included in the other group.

In another embodiment of the invention, the interpolation means interpolates at least a direct current component of the lost data by selectively using data of pixels in a peripheral portion of an image block corresponding to the lost data and data of pixels externally adjacent to the image block among the data included in the other group.

According to another aspect of the invention, the apparatus for recording and reproducing data includes: recording medium traveling means for making a recording medium to travel in a first direction; rotating drum means having a head used for recording and reproducing the data, the head traversing the recording medium obliquely to the first direction, whereby tracks which are oblique to the first direction are formed on the recording medium; recording means for recording data in a predetermined portion of the recording medium, the predetermined portion being passed by the head at a first speed of the recording medium; and reproducing means for reproducing the data re-

corded in the predetermined portion of the recording medium, wherein the data is divided into a plurality of sync blocks, and the plurality of sync blocks are recorded on each of the tracks and pilot signals are recorded periodically in several successive tracks, and the reproducing means includes: reproduced position detecting means for detecting the predetermined portion of the recording medium in the reproduction at a second speed, being not equal to the first speed, and for generating a timing signal indicating a position of a reproduced signal corresponding to the predetermined portion; tracking error detecting means for detecting a relative positional deviation of the track with respect to the head from the pilot signal included in the reproduced signal, and for generating a tracking error signal depending on the detected relative positional deviation; sampling means for sampling the tracking error signal in accordance with the timing signal; and adjusting means for adjusting the position of the track relative to the head path, so that the tracking error signal is substantially set to be 0.

In one embodiment of the invention, each of the plurality of sync blocks includes ID information for identifying the sync block, and the reproduced position detecting means generates the timing signal when the ID information matches predetermined ID information to be detected.

In another embodiment of the invention, each of the plurality of sync blocks includes ID information for identifying the sync block, and the reproduced position detecting means generates the timing signal at a timing based on the rotation of the rotating drum means and the ID information.

In another embodiment of the invention, the apparatus further includes: correcting means for, when the timing signal is not obtained from the reproduced position detecting means, shifting the position of the track relative to the head path by a predetermined amount until the pulse signal is obtained.

In another embodiment of the invention, the data is video signal which is digitized and compressed, and the video signal includes a plurality of video frames.

With the above construction, according to the invention, it is possible to reproduce a fundamental data group which is required for the reproduction at a plurality of high speeds.

If the recorded data is a video signal, it is possible to perform the high-speed reproduction at a plurality of high speeds, and the thus reproduced image matches the visual sense of human beings, i.e., the image has the characteristics that the image has a higher quality as the reproduction speed is lowered.

According to the invention, if video-frame page information such as time record and other informa-

tion are inserted at the first position and the second position, the page information can be stably obtained in the searching. Thus, the method of the invention is very advantageous in that the search can be performed by designating a page of frame or the like.

The fundamental data group used for the high-speed reproduction is recorded or reproduced in the vicinity of the center of the track, so that it is possible to obtain data with relatively few errors during the high-speed reproduction.

To the fundamental data group for the high-speed reproduction, an identification code indicating the contents of data and the position on a recording medium is added. By using the code for the purpose of the control of the head path, the head path can be controlled with high accuracy during the high-speed reproduction.

Thus, the invention described herein makes possible the advantages of (1) providing a signal recording and reproducing apparatus of helical scan type capable of variable-speed reproduction at three or more different medium speeds without additional data for high-speed reproduction, (2) providing a signal recording and reproducing apparatus of helical scan type by which an image reproduced at a high speed matches the visual senses of human beings so that the image can be viewed comfortably, when digital image signals are recorded as the recorded data, (3) providing a signal recording and reproducing apparatus which performs the high-speed reproduction even when part of the data for high-speed reproduction is lost during the high-speed reproduction, (4) providing a highly accurate control method by which the head path is controlled with high accuracy during the high-speed reproduction, and (5) providing a signal recording and reproducing apparatus of helical scan type which stably obtains data during the high-speed reproduction.

These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Figures 1 through 16 are diagrams each showing a tape pattern and a head path in a signal recording and reproducing apparatus according to the invention.

Figure 17 is a view showing the construction of a scanner of a recording and reproducing apparatus of helical scan type.

Figure 18 is a concept diagram showing the reproduced output.

Figure 19 is a view showing the construction of a rotating drum having two heads.

Figure 20 is a diagram showing the construction of a rotating drum having four heads.

Figure 21A is a diagram showing a DCT coefficient obtained by a DCT.

Figure 21B is a diagram showing a quantization table.

Figure 22 is a diagram showing a zigzag scan.

Figure 23 is a diagram illustrating a preferential classification method for DCT coefficients.

Figure 24 is a diagram showing the block divisions of a screen.

Figures 25A to 25C are diagrams each showing a priority based on the position of DCT blocks in the screen.

Figure 26 is a diagram showing an example for determining a priority depending on the position of a DCT block and a component in the DCT block.

Figures 27 and 28 are concept diagrams illustrating a process for producing a plurality of synchronization blocks, based on the priority determined depending on the position of a DCT block and a component in the DCT block.

Figures 29A and 29B are concept diagrams showing a subsampling of a DCT block.

Figures 30A and 30B are concept diagrams showing a recorded pattern of subsampling data.

Figures 31A to 31D are concept diagrams showing the recorded portions of identification codes.

Figures 32A and 32B are concept diagrams showing the relationship between the reproduction output during the high-speed reproduction and the center identification code.

Figure 33 is a concept diagram showing the process for separating the bit stream into intra-frame compressed data and inter-frame compressed data, and for adding an ID and a pointer.

Figure 34 is a concept diagram showing the transmission of data with a higher priority and data with a lower priority.

Figures 35A and 35B are diagrams each showing the construction of a signal recording and reproducing apparatus.

Figure 36 is a block diagram showing the construction of a signal recording and reproducing apparatus in a first example according to the invention.

Figure 37 is a block diagram showing the construction of a signal recording and reproducing apparatus in a second example according to the invention.

Figure 38 is a block diagram showing the construction of a signal recording and reproducing apparatus in a third example according to the invention.

Figure 39 is a block diagram showing the construction of another signal recording and reproducing apparatus in the third example according to the invention.

Figure 40 is a block diagram showing the construction of a signal recording and reproducing apparatus in a fourth example according to the invention.

Figure 41 is a block diagram showing the construction of a signal recording and reproducing apparatus in a fifth example according to the invention.

Figure 42 is a block diagram showing the construction of a signal recording and reproducing apparatus in a sixth example according to the invention.

Figure 43 is a block diagram showing the construction of a signal recording and reproducing apparatus in a seventh example according to the invention.

Figure 44 is a block diagram showing the construction of an image compression circuit.

Figure 45A is a block diagram showing the construction of a data shuffler.

Figure 45B is a block diagram showing the construction of a memory for the data shuffler.

Figure 45C shows an exemplary pattern of recorded tracks.

Figure 45D is a diagram showing the structure of a sync block.

Figure 45E shows the switching timing of a selector.

Figure 46 is a block diagram showing the construction of an image reconstruction circuit.

Figure 47A is a block diagram showing the construction of a bit stream separation circuit.

Figure 47B is a block diagram showing the construction of a bit stream reconstruction circuit.

Figure 48 is a block diagram showing the construction of a signal recording and reproducing apparatus in an eighth example according to the invention.

Figures 49A to 49D are schematic diagrams for illustrating the operation of the signal recording and reproducing apparatus in the eighth example of the invention.

Figure 50 shows the data structure in tracks.

Figure 51 is a diagram showing the construction of a tracking error detector.

Figure 52 is a diagram showing a tracking controller.

Figure 53 shows signal waveforms in the tracking controller.

Figure 54 is a block diagram showing the construction of a signal recording and reproducing apparatus in a ninth example according to the invention.

Figure 55 is a diagram showing the construction of a timing corrector, the tracking controller, sampler, and a delayed pulse generator.

Figure 56 is a flowchart illustrating the operation of the timing corrector and part of the operation of the tracking controller.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be described by way of illustrative examples with reference to the accompanying drawings.

Figures 35A and 35B each show the construction of a signal recording and reproducing apparatus of helical scan type.

Figure 35A shows the construction of the signal recording and reproducing apparatus when the input signal is a digital signal. Herein, a signal which is to be recorded on a recording medium is referred to as a recording signal, and a signal which is reproduced from the recording medium is referred to as a reproduced signal.

A digital signal is input through an input terminal 58 and then fed to a recording signal processor 59 where a prescribed signal processing is performed. Then, the processed digital signal is recorded on a tape-like recording medium 15 by using a recording head 60. The recording is performed in a helical scan manner.

Figure 17 shows an exemplary construction of a scanner of helical scan type.

A cylindrical rotating drum 37 rotates at a prescribed angle with respect to the traveling direction of the tape-like recording medium 15. The rotating drum 37 has recording and reproducing heads 38(L) and 39(R). The recording and reproducing heads 38(L) and 39(R) and the rotating drum 37 rotate at equal speed. The tape-like recording medium 15 is wrapped in a helix around the rotating drum 37 by 180°. The tape-like recording medium 15 travels at a predetermined speed. Figure 19 is a view of the scanner shown in Figure 17 when it is viewed in the direction along the rotation axis of the rotating drum 37.

By using the scanner of helical scan type with the above-described construction, the signal is recorded on the tape-like recording medium 15.

In the scanner of helical scan type, the recording head moves obliquely to the traveling direction of the tape-like recording medium. As a result, a plurality of tracks are formed on the tape-like recording medium at a prescribed angle with respect to the traveling direction of the tape-like recording medium. The reference numerals 1 and 2 in Figure 1 indicate the recorded track patterns formed by the recording head.

In the reproduction, the tape-like recording medium is made to travel at the same speed as in the recording, and the rotating drum 37 is made to rotate at the same speed as in the recording, whereby the reproducing head can accurately scan the recorded tracks. As a result, the recorded data is accurately reproduced. In most cases, the reproducing head is also used as the recording head. The recording and reproducing heads 38(L) and 39(R) are usually mounted on the rotating drum 37 in such a manner that they are diametrically opposed so that the corresponding tracks have respectively different azimuth angles. This makes it possible to reproduce signals from only the desired tracks, even when the reproducing head scans positions which deviate somewhat from the desired tracks during the reproduction. The thus reproduced signals are processed back into the original signals by a reproduced signal processor 62 which performs a processing inverted from that in the recording signal processor 59, and then output from an output terminal 63.

Figure 35B shows the construction of the signal recording and reproducing apparatus when the input signal is an analog signal.

The analog signal is input through the input terminal 58 and then converted into a digital signal by an A/D converter 64. Thereafter, the digital signal is recorded on the tape-like recording medium 15 via the same process as described with reference to Figure 35A. In the reproduction, the digital signal recorded on the tape-like recording medium 15 is reproduced via the same process as described with reference to Figure 35A. The reproduced digital signal is converted into the original analog signal by a D/A converter 65, and then output from the output terminal 63.

Figures 1 to 8 show exemplary patterns of tracks recorded by the signal recording and reproducing apparatus according to the invention.

In Figure 1, the tracks 1(L) and 2(R) are tracks recorded by the recording and reproducing heads 38(L) and 39(R) shown in Figures 17 and 19 where the magnetic tape 15 is made to travel at a 1-fold speed. Herein, a 1-fold speed, i.e., a tape speed equal to the normal speed is referred to as x1 speed, and an N-fold speed, i.e., a tape speed which is N times as fast as the normal speed is referred to as xN speed. In the same way, a -N-fold speed, i.e., a tape speed which is -N times as fast as the normal speed is referred to as x(-N) speed.

It is assumed herein that the rotation speed of the rotation head 37 is constant. A thick arrow 3 shows a head path when the magnetic tape 15 is made to travel at x9 speed. In this case, the recording and reproducing heads 38(L) and 39(R) obliquely traverse nine tracks in one scanning. A thin arrow 4 shows a head path when the magnetic



tape 15 is made to travel at x3 speed. In this case, the recording and reproducing heads 38(L) and 39-(R) obliquely traverse three tracks in one scanning.

In Figure 1, solid portions 5 are areas which are traced in both cases of x3 and x9 speeds. Accordingly, if data which is utilized for high-speed reproduction is located in the portions 5, it is possible to perform the reproduction at x3 and x9 speeds. The areas which are traced in both cases of x3 and x9 speeds may be portions 6 which are located at both ends of the tracks, as is shown in Figure 2. Alternatively, data may be located at both of the portions 5 and 6, as is shown in Figure 3.

Figures 4 to 6 each show a head path when the magnetic tape 15 is made to travel at x(-3) speed and a head path when the magnetic tape 15 is made to travel at a x(-9) speed. In Figure 4, a thin arrow 7 indicates a head path in the case of x(-9) speed, and a thick arrow 8 indicates a head path in the case of x(-3) speed. It is seen from Figures 4 and 5 that from the portion from which data can be reproduced in both cases of x3 and x9 speeds, data can also be reproduced in both cases of x(-3) and x(-9) speeds. Figure 6 shows that the portions corresponding to the portions 5 and 6 shown in Figure 3 are commonly traced by the head in both cases of x(-3) and x(-9) speeds. In both cases of x(-3) and x(-9) speeds, the portion 5 in the vicinity of the center of the track and the portions 6 in the vicinity of the ends of the track are scanned in one scanning.

Since the data is recorded on the portions 5 and 6 at respective azimuth angles which are different from each other, it is impossible to obtain the data recorded on the portions 5 and 6 in one scanning. However, in the case where data was recorded in a no-azimuth recording manner in which a guard band is provided between tracks, the data can be recorded on the portions 5 and 6 at the same azimuth angle. Therefore, it is possible to obtain the data recorded in both of the portions 5 and 6 in one scanning.

As described above, the portion which is commonly scanned by the reproducing head is not limited to the portions specifically shown in Figures 1 through 8. The portion may be any portion, insofar as the portion is commonly traced by the head at various different tape speeds, and data can be reproduced from the portion. In any case, a track having such a portion is periodically selected from recorded tracks. In the above description, the cases of the x( $\pm$ 3) speeds and the x( $\pm$ 9) speeds are exemplarily described. However, any combination of tape speeds can be used.

As is shown in Figures 17 and 19, in the case where the recording and reproducing heads are attached on the rotating drum in such a manner that they are diametrically opposed, it is preferable

to use tape speeds multiplied by the power of an odd number, considering the head azimuth. This is because, in the case of tape speeds multiplied by the power of an odd number, there are many portions from which data can be commonly reproduced at respective tape speeds, so that high efficiency is achieved. However, the tape speeds are not necessarily limited to those multiplied by a power of an odd number. Considering the head azimuth, the head path depends of the wrapping angle of the tape on the rotating drum, but it is sufficient that data is located at a position which is commonly traced by the head.

In the above description, the recording and reproducing heads with different azimuths are mounted on the rotating drum in such a manner that they are diametrically opposed. Alternatively, another construction can be used. For example, a pair of heads (L, R) are mounted on the rotating drum at one side.

Figure 7 shows another exemplary pattern of tracks recorded by the signal recording and reproducing apparatus of the invention. This example of recorded pattern is obtained by performing the recording at a tape speed multiplied by the Nth power of 2 in the case where the rotating drum 37 has a pair of heads 41(L) and 42(R) at one side thereof, as is shown in Figure 20. The pair of heads 41(L) and 42(R) have respective azimuths which are reversed from each other. In Figure 20, the heads 44(R) and 45(L) are auxiliary heads for reproduction. The auxiliary heads for reproduction are optionally used.

Figure 7 shows the head paths in the cases of x4 and x8 speeds by using the rotating drum 37 having the construction shown in Figure 20 (it is assumed that the auxiliary heads for reproduction are not used). A thin arrow 9 indicates the head path in the case of x8 speed. A thick arrow 10 indicates the head path in the case of x4 speed. The portion which is commonly traced in both cases of x8 and x4 speeds is the area 11. In Figure 8, a thin arrow 12 indicates the head path in the case of x(-8) speed. A thick arrow 13 indicates the head path in the case of x(-4) speed. The portion which is commonly traced in both cases of x(-8) and x(-4) speeds is the area 14. The area 14 is identical with the area 11 which is commonly traced in both cases of x8 and x4 speeds. Therefore, if data is recorded in the area 14 shown in Figure 8, the data can be used for both the forward and the reverse directions.

These portions are not limited to the specific portions shown in the figures. Alternatively, the portions may be areas which are commonly traced by the head at various tape speeds. In any case, a track having such a portion is periodically selected from the recorded tracks. When the data is to be

reproduced at tape speeds obtained by multiplying the normal tape speed by even numbers, considering the head azimuth, it is more efficient to mount both the heads (L, R) on the rotating drum at one side. However, the construction is not limited to this specific type. In addition, as is shown in Figure 20, if the auxiliary heads for reproduction are mounted on the rotating drum on the other side, the area which is capable of being commonly traced at various tape speeds can be increased to be twice as large as in the case without the auxiliary heads for reproduction.

#### Example 1

Figure 36 shows the construction of a signal recording and reproducing apparatus in the first example according to the invention. In the following description, it is assumed that the input signal is the analog video signal. However, the input signal is not limited to the analog video signal.

Hereinafter, a process for recording data at a predetermined position of a tape-like recording medium 15 is described.

An analog video signal is input through an input terminal 58. The input analog video signal is converted into a digital signal having a predetermined number of quantization bits at a predetermined sampling clock, by an A/D converter 64. A signal processor 66 performs a prescribed signal processing for the digital signal.

The prescribed signal processing is, for example, a process for removing a redundant component of the input image and compressing the image. Figure 44 shows an exemplary compression circuit. The compression circuit compresses the data by using the motion compensation DCT method. In the motion compensation DCT method, one frame which is periodically selected from the input image data is compressed by using the data in the frame, and for each of the remaining frames, the difference from the respective previous frame is compressed and transmitted. For the intra-frame compression and the inter-frame compression, a discrete cosine transform which is one of orthogonal base transforms is used. In addition, when the difference between frames is to be calculated, a motion vector of the image between the current frame and the previous frame is first detected, and then the difference is obtained after the motions are compensated based on the motion vector. Thus, the compression efficiency is remarkably enhanced.

Hereinafter, the operation of the compression circuit of Figure 44 is described. The image data is input through an input terminal 119. A subtracter 120 is used for calculating the difference from the previous frame. Refresh switches 126 and 127 are

turned on and off depending on either the intra-frame compression or the inter-frame compression. In the case of the intra-frame compression, the refresh switches 126 and 127 are turned off. As a result, the subtracter 120 does not operate. The input image data is subjected to the discrete cosine transform (DCT) by a DCT circuit 89. The discrete cosine transform is usually performed in two dimension. If the discrete cosine transform is performed for each block of  $8 \times 8$ ,  $8 \times 8$  coefficients are obtained as the result of the transform. Figure 21A shows the  $8 \times 8$  coefficients obtained by the DCT. As for the coefficients obtained by the DCT in the figure, the upper-left one is the direct current (DC) component. the more right positions indicate the horizontal higher-frequency components, and the more down positions indicate the vertical higher-frequency components. The respective data obtained by the DCT is inherently a successive amount. However, since the operation is performed by using the digital circuit, each of the 64 coefficients is obtained as a digital value having a predetermined bit width. Next, for the data, an optimum bit assignment is performed for each frequency component by a quantizer 90. Generally, since the lower-frequency components are important for constituting the image, the bit assignment to the lower frequency components is made larger. Since the higher-frequency components are not so important for constituting the image, the bit assignment thereto is made smaller. Specifically, by using a quantization table shown in Figure 21B, an optimal bit is assigned by performing a dividing operation for the coefficient obtained as the result of the DCT. In the exemplary quantization table shown in Figure 21B, the DC components are divided by 8. This means that the lowest three bits of the DC component is rounded down. In this way, the data in which the optimal bit is assigned to each frequency component is output from the quantizer 90. A VLC circuit 91 performs the variable length coding for the output of the quantizer 90. In the variable length coding, a shorter code length is assigned to data which appears with a statistically higher frequency. By using the variable length coding, the statistically redundant component included in the data is removed. In such coding, the Huffman code is generally used. However, some devices use the variable length coding and other devices do not use the variable length coding. Thus, the intra-frame compressed data is output from an output terminal 121.

The output of the quantizer 90 is recovered to the original one by an inverse quantizer 97. Specifically, the inverse quantizer 97 multiplies the frequency components by the respective values in the quantization table shown in Figure 21B, in the reversed manner from the quantization. As a result,

the amplitude of each frequency component is recovered to the original amplitude. Each coefficient whose amplitude is recovered to the original one by the inverse quantization is reconstructed into the original data by an IDCT circuit 98. If the reconstructed image data is the intra-frame image data, an adder 122 does not operate. Thereafter, reconstructed image data is delayed by one frame by a delay circuit 123. The delayed image data is input into a motion estimation circuit 125. The motion estimation circuit 125 calculates the motion amount from the input image data. The motion estimation circuit 124 moves the position of the image data in accordance with the calculated motion amount. The image data which is thus motion-compensated is used for calculating a difference from the next image data by the subtracter 120.

The image data of succeeding few frames is used for compressing the differences with respect to the previous frames. The operation as a system is the same as that in the intra-frame compression. However, in the inter-frame compression, the refresh switches 126 and 127 are turned on. The refresh switch 127 is turned on when the difference between frames is to be calculated. When the refresh switch 127 is turned on, the subtracter 120 starts to operate. The refresh switch 126 is repeatedly turned on or off at the same period as that of the refresh switch 127. During the on period of the refresh switch 126, the adder 122 operates, so that the inter-frame difference data and the data of the previous frame are added to each other. The added data is used for reconstructing the frame.

The VLC circuit 91 also performs the variable length coding for the inter-frame compressed data. As a result, the intra-frame compressed data and the inter-frame compressed data are periodically output from the output terminal 121. Usually, the intra-frame compressed data and the inter-frame compressed data are output in accordance with the order of zigzag scan as shown in Figure 22. The cycle of the intra-frame compression is appropriately determined depending on the compression rate and the like.

One such image compression method is the MPEG compression method which is, for example, described in the journal INTERFACE, August, 1992, page 124. The method is described in the case of intra-frame in which each intra-frame coding is performed for several frames.

Referring back to Figure 36, the data which has been subjected to the signal processing required for the recording is input into a data shuffler 67. The data shuffler 67 rearranges the order of data so that specific data can be located in an area which is commonly traced by the reproducing head at a plurality of predetermined tape speeds.

The data shuffler 67 has, for example, a construction shown in Figure 45A. A signal is input through an input terminal 128. The input signal is separated into data to be recorded in an area which is commonly traced by the reproducing head at a plurality of predetermined tape speeds (i.e., data for high-speed reproduction) and the other data.

In the case where the input signal is a video signal, it is preferable that the data to be recorded in the area which is commonly traced by the reproducing head at a plurality of predetermined tape speeds may be data which constitutes one frame (or one field). Such data may be, for example, the data which is subjected to the intra-frame compression, or the low-frequency components or the upper bit components of the data. The data for high-speed reproduction and the other data which are separated are rearranged by a shuffling memory 130 in such a manner that the recorded pattern on the tape corresponds to the above-described recorded pattern. The rearranged data is output from an output terminal 131.

Referring back to Figure 36, to the data which is shuffled for the high-speed reproduction, an error correction code is added by an error correction code adding circuit 68. Thereafter, the data is subjected to the modulation required for the recording by a modulator 69. Then, the modulated data is recorded on the tape-like recording medium 15 by using the recording head 60.

Next, the process for reproducing the data recorded on the tape-like recording medium 15 is described. The data reproduced by the reproducing head 61 is demodulated by a demodulator 70, and any correctable error is corrected by an error corrector 71. Then, the order of the data is recovered to be the original one by a data deshuffler 72. The data deshuffler 72 serves to recover the locations of the data for high-speed reproduction and the other data which are periodically located on the tracks on the tape by the data shuffler 67 into the original locations.

The data in which the order is recovered by the data deshuffler 72 is reconstructed into the original image by a signal processor 73.

The signal processor 73 performs the reversed processing from that of the signal processor 66. The image reconstructing circuit corresponding to the image compression circuit shown in Figure 44 is shown in Figure 46. In this example, it is assumed that the variable length coding (VLC) is not performed during the recording, so that a circuit for decoding the variable length coding (VLD) is not shown in Figure 46. When the VLC is performed during the recording, it is necessary to first perform the VLD during the reproduction. The quantized data input from the input terminal 132 to which the

VLC is performed if necessary is reversed to the original one by an inverse quantizer 134. The inverse quantizer 134 is identical with the inverse quantizer 97 for the recording. The data which is inversely quantized is then subjected to the inverse discrete cosine transform by an IDCT 134. If the output data from the IDCT circuit 134 is the intra-frame compressed data, an adder 138 does not operate. If the input data is the inter-frame difference data, the reconstructed signal output to an output terminal 139 is delayed by one frame by a delay circuit 135. The delayed reconstructed signal is compensated for the motion by a motion compensation circuit 136. Then, the motion-compensated signal is added to the output data of the IDCT circuit 134, and then output from the output terminal 139.

The signal is finally recovered to be the original analog video signal by a D/A converter 65, and then output from an output terminal 63.

During the high-speed reproduction, it is sufficient to reproduce only the data for high-speed reproduction in accordance with the above-described reproduction process.

For the data for high-speed reproduction, other than the intra-frame compressed signal, a signal required for search such as a signal indicating the time of recorded data may be used. In such a case, the signal processors 66 and 73 for recording and reproduction can be constructed as a circuit corresponding to the signal contents. Alternatively, if an identification code is added to the data for high-speed reproduction, and the data contents can be identified based on the identification code, the application flexibility of the apparatus is enhanced, and the apparatus can have greater versatility.

As described above, according to the signal recording and reproducing apparatus of the first example according to the invention, the data for high-speed reproduction is located in an area which is commonly traced by the reproducing head at three or more reproduction speeds, so that the required data can be obtained at each of the three or more reproduction speeds.

## Example 2

Figure 37 shows the construction of a signal recording and reproducing apparatus of a second example according to the invention.

A video signal which is input from an input terminal 58 and converted into a digital form by an A/D converter 64 is compressed by an image compression circuit 74. For example, the image compression circuit 74 may have the above-described construction shown in Figure 44. However, the image compression circuit 74 is not essential to the implementation of the invention, so that it is not

necessarily provided. The most fundamental data among the image data compressed by the image compression circuit 74 is transferred to an A data buffer 76 by a data distributor 75. The second most fundamental data among the compressed image data is transferred to a B data buffer 77 by the data distributor 75. The remaining image data is transferred to a C data buffer 78 by the data distributor 75. The data buffers 76 to 78 are memories for temporarily storing the respective data. The reading of data from the data buffer 76 - 78 is stopped until the head comes to a predetermined position on the tape.

When the head comes to the predetermined position on the tape, a switch 79 operates so as to output the data from one of the data buffers 76 - 78. To the output data, a data ID indicating the position and components of the image is added by an ID adding circuit 80. Then, an error correction code is further added and then the data is modulated by a transmission encoder 81. The modulation is performed by a general digital modulation method such as NRZI or 8-14. The data modulated by the transmission encoder 81 is recorded on the tape 15 via a recording amplifier 82 and a head 60. The construction of the rotating drum is shown in Figure 19. The heads which are mounted on the rotating drum so that they are diametrically opposed so as to have azimuth angles (L, R) which are different from each other.

In the reproduction, the reproduced signal reproduced via a head 61 is fed through a preamplifier 83 and a reproduction equalizer 84, and demodulated by a transmission decoder 85, so that the error is corrected. The reproduced data is subjected to the decode processing which is reversed from the compression during the recording by a decoder 86, and stored at a location of a frame buffer 88 designated by an address examined in an ID detector 87. The data in the frame buffer 88 is sequentially read out at a given rate, and then converted into an analog form by a D/A converter. Then, the analog signal is output as a video signal.

Figure 9 shows a pattern recorded by the signal recording and reproducing apparatus of the second example according to the invention. In Figure 9, the recorded tracks 1 and 2 are obliquely formed on the tape 15.

Into first portions 5 on the tracks, the first fundamental data from the A data buffer 76 shown in Figure 37 is written. Into second portions 16, the second fundamental data from the B data buffer 77 is written. The first portion 5 is formed on a portion of a track which is selected as every ninth track. The second portion 16 is formed on a portion of a track which is selected as every third track, but the second portion 16 does not overlap the first portion

5. The first portions 5 are successively formed on the tracks alternately having different azimuth angles (R, L). Also, the second portions 16 are successively formed on the tracks alternately having different azimuth angles (R, L).

During the high-speed reproduction, the head scans the tape 15 in such a manner that the head obliquely traverses the tracks. In addition, the length of data along the tape extending direction should be set so as to be equal to, or shorter than the length of data which can be reproduced at the reproduction speed. If the head width is set to be about 1.5 times as large as the track width, the reproducible data length at x9 speed is about 1/6 of the total track length. The data length becomes larger as the tape speed is lowered. Accordingly, at x2 speed, it is possible to obtain the data on almost all of the tracks.

The solid line 3 shown on the tape 15 indicates the head path on the tape 15 when the tape is made to travel at x9 speed. As is apparent from Figure 9, the head path obliquely traverses nine tracks at one time. When a certain head path starts from a track having an azimuth angle R, the next head path starts from a track having an azimuth angle L. Thus, the azimuth angles of the points from which the head path starts are alternately R and L.

The broken line 4 shown in the tape 15 indicates the head path on the tape 15 when the tape is made to travel at x3 speed. As is apparent from Figure 9, the head path obliquely traverses three tracks at one time. When a certain head path starts from a track having an azimuth angle R, the next head path starts from a track having an azimuth angle L. Thus, the azimuth angles of the points from which the head path starts are alternately R and L.

As is seen from Figure 9, the first portions 5 are commonly traced at both x3 and x9 speeds, so that the first fundamental data which is required for the special reproduction can be obtained at respective x3 and x9 speeds. In these cases, the tape 15 is made to travel by means of a capstan motor and a pinch roller the same as in a usual VTR or the like. However, it is necessary to perform phase control in the case of x3 or x9 speed, in order for the head to stably pass the portion 5. This technique is usually used for the purpose of fixing the noise bar at a given position in the screen so as to eliminate trouble in the displayed image, in a VTR for domestic use of VHS type or the like. With such a construction, it is possible to stably reproduce the specific reproduced image at both of x3 and x9 speeds. Only during the x3 speed, the second fundamental data in the second portions 16 can be additionally obtained, so that it is possible to obtain a reproduced image with higher quality than in the

case of a reproduction at x9 speed. In general, the motion of the displayed image is slower at the lower reproduction speed, so that a higher quality is required for the lower reproduction speed. Thus, according to the second example, a system with a good balance can be constructed. In Figure 9, the length of the second portion 16 along the track direction is larger than that of the first portion 5 along the track direction. This is because, as the reproduction speed is lowered, the angle formed by the head and the track becomes smaller, so that the period in which the data can be effectively obtained is extended.

Figure 10 shows another pattern recorded by the signal recording and reproducing apparatus of the second example according to the invention. In Figure 10, recorded tracks 17 are obliquely formed on the tape 15, the same as in the pattern shown in Figure 9. In first portions 18 on the tracks 17, the first fundamental data from the A data buffer 76 shown in Figure 37 is written. In the second portions 19 on the tracks 17, the second fundamental data from the B data buffer 77 is written. The second portions 19 are formed on the tracks on which the first portions 18 are formed. The solid line 20 shown on the tape 15 indicates the head path on the tape 15 when the tape 15 is made to travel at x9 speed. The broken line on the tape 15 indicates the head path when the tape 15 is made to travel at x3 speed.

As is seen from Figure 10, the first portions 18 are traced by the head paths 20 in the case of x9 speed. The second portions 19 are traced by the head paths 21 in the case of the x3 speed. An area of the second portion 19 is larger than that of the first portion 18. This is because, as the reproduction speed is lowered, the angle formed by the head and the track becomes smaller, so that the portion which can be traced by the head is widened.

Figures 9 and 10 show the cases in which the second portions are formed at the different positions. Alternatively, these cases may be combined. In such a case, a larger number of second portions can be formed. In addition, since the data is located on a portion of the track recorded at the normal speed (x1 speed), it is possible to obtain without failure data in the reproduction at the normal speed. Therefore, the first and the second fundamental data can be used with the data for the normal reproduction.

Thus, it is possible to constitute a system which can attain a special reproduction without increase in total information amount. In the case where the amount of the first and second fundamental data is limited to be smaller than the amount of the remaining data, if the first and second fundamental data is separately located from

the data for normal reproduction, the total information amount is not so increased. The first and second fundamental data can be located on both of a portion for normal reproduction and a portion for special reproduction. In such a case, it is unnecessary to provide the memory for storing the first and second data in the reproduction at normal speed, so that the reproduction circuit is simplified.

It is known that among the DCT coefficients shown in Figure 21A, the one which is located at the upper and leftward position is generally more important for image reproduction. For example, the image data may be classified into three types. Specifically, the DC component at the uppermost and leftmost position is used as the first fundamental data, the A12 and A21 components are used as the second fundamental data, the remaining components are used as the other data.

Alternatively, the image data can be classified into three types in the following manner. Only the upper bits of the DC component are used as the first fundamental data, only the upper bits of the A12 component and the upper bits of the A21 component are used as the second fundamental data, and the remaining components including the lower bits of the DC component, the lower bits of the A12 component, and the lower bits of the A21 component are used as the other data.

It is not necessary that the fundamental data to be used for high-speed reproduction is extracted from all of the frames of the original image. For example, the fundamental data for high-speed reproduction can be extracted from frames which are reduced at a predetermined cycle. For example, the first and the second fundamental data can be extracted from the frames which are selected at a rate of one out of 8 frames. In such a case, the information amount required for the first and second fundamental data can be reduced to be 1/8.

In this invention, it is possible to handle the above-described intra-frames as the first fundamental data. Alternatively, the first and second fundamental data can be extracted from the intra-frames. In the case where the video signal is of the component type and the video signal includes color difference signals in addition to the luminance signal, the first and second fundamental data can be extracted from the luminance signal and the color difference signals, considering the importance for constituting the image. Moreover, the first and second fundamental data can be extracted from the information indicating the page of video frame such as a time code, instead of the video signal, and the extracted data can be located in the first and second portions. In such a case, in the high-speed reproduction, the search and the like can be automatically performed by detecting the time code.

In the above-described example, the heads are mounted on the rotating drum 37 in such a manner that they are diametrically opposed, as is shown in Figure 19. The heads 38 and 39 have respective azimuth angles R and L which are different from each other. However, if a guard band is provided between the tracks, a rotating drum having heads with the same azimuth angles can attain the same effects as in the case of the rotating drum shown in Figure 19.

Figure 20 shows the construction of the helical scan type scanner. The heads 41 and 42 having respective azimuth angles which are different from each other, are mounted on the rotating drum 37 at adjacent positions with different track pitches in height.

Figure 11 shows the recorded pattern on the tape 15 formed by the signal recording and reproducing apparatus according to the invention, when the rotating drum shown in Figure 20 is employed. In Figure 11, the first fundamental data 22 and the second fundamental data 23 are located every 8 paired tracks on the tape 15. For simplicity, in Figure 11, the paired tracks formed by the heads 41(L) and 42(R) are represented by one track. For the same reason, the head paths are represented by a center line between the two head paths.

The solid line 24 indicates the head-pair path in the case of x8 speed. The one dot chain line 25 indicates the head-pair path in the case of x4 speed. The broken line 26 indicates the head-pair path in the case of x2 speed.

As is apparent from Figure 11, the first fundamental data can be obtained at all of the special reproduction speeds, i.e., x2, x4, and x8 speeds. Furthermore, even in the case of the reproduction at x8 speed, it is possible to surely obtain a predetermined special reproduction image quality. In addition, in the cases of the reproduction at x2 and x4 speeds, the second fundamental data can be obtained together with the first fundamental data, so that a special image with improved quality can be obtained. As is seen from Figure 11, there is an area which is traced by the head only in the case of x2 speed. Thus, it is possible to locate the third fundamental data in this area.

Figure 12 shows the detailed positional relationship between the tracks and the head path shown in Figure 11. As is shown in Figure 12, there are paired tracks 27 and 28 formed on the tape 15 by the head with azimuth angles R and L, respectively. The paired tracks 27 and 28 obliquely intersect the head paths 29 and 30 formed by the heads with azimuth angles R and L. The fundamental data is located in the intersecting portion.

Next, an example case where only one of two head-pairs mounted on the rotating drum shown in

Figure 20 is used for normal recording and reproduction is described. In this example, only one head-pair which is mounted at one side of the rotating drum having two head-pairs is used during the recording. Accordingly, the number of tracks formed per unit time is half that compared with the case of two head-pairs. This is effective in the case of a long-time mode at a half data rate. In such a case, even if the one head-pair which is not used is positioned on the tape, data is not recorded.

Figure 13 shows the recorded pattern formed on the tape 15 by the signal recording and reproducing apparatus of the invention when only one head-pair mounted at one side of the rotating drum shown in Figure 20 is used. In Figure 13, the recorded tracks 17 are formed on the tape 15 by the head-pair. For simplicity, in Figure 13, the paired tracks formed by the two heads 41(L) and 42(R) are represented by one track. Also, the head paths of the two heads are represented by a center line of the two head paths. The first fundamental data 31 and the second fundamental data 32 are located every eighth track, respectively. The solid line 33 indicates the head path in the case of x4 speed. The dotted line 34 indicates the head path in the case of x8 speed. As is seen from Figure 13, the first fundamental data can be obtained in the reproduction at x8 speed, thereby surely obtaining a special reproduced image with a good quality. In addition, in the reproduction at x4 speed, the second fundamental data can be obtained together with the first fundamental data, whereby it is possible to reproduce a special reproduced image with an improved image quality.

Now, the head-pair which is not used during the recording (i.e., the reproduction auxiliary head-pair) is described. The one dot chain line 35 in Figure 13 indicates the path of the reproduction auxiliary head-pair at x8 speed. The path of the reproduction auxiliary head-pair depicts another path which is parallel to the path of the recording head, and positioned at the middle between the paths of the recording head. This is because the construction of the reproduction auxiliary head-pair is the same as that of the recording head-pair, but the reproduction auxiliary head-pair is mounted so as to be diametrically opposed to the recording head-pair. As is seen from Figure 13, the path 35 of the reproduction auxiliary head passes the second fundamental data, so that both the first and the second fundamental data can be obtained in the reproduction at x8 speed. As a result, the image obtained in the reproduction at x8 speed has the same quality as that obtained in the reproduction at x4 speed.

### Example 3

Hereinafter, a signal recording and reproducing apparatus of a third example according to the invention will be described. Figure 38 shows the construction of the signal recording and reproducing apparatus of the third example. As is shown in Figure 38, the signal recording and reproducing apparatus includes a priority-based classification circuit 92, a sync block generation circuit 93, the formatter 94 and a DCT block reconstructor 95.

The digital video signal input through the input terminal 58 is compressed by using the above-described DCT, so as to reduce the redundancy. In this example, it is assumed that the compression is the intra-frame compression, but alternatively, the inter-frame compression can also be used. The DCT circuit 89 divides the digital data constituting one screen into  $(M \times N)$  blocks (B11 - BNM) as is shown in Figure 24, and performs DCT for the respective  $(M \times N)$  blocks. The transform coefficients (DC, A12-A88 in Figure 21A) obtained by the DCT represent the orthogonal base components in two dimension.

The quantizer 90 quantizes the respective transform coefficients obtained by the DCT. The quantization can be attained by dividing the transform coefficient by a predetermined value at a position corresponding to the transform coefficient. For example, the quantization for the DC component is attained by dividing the DC component by 8. The quantization for the A88 component is attained by dividing the A88 component by 83. The quantization is performed for all of the DCT blocks divided by the DCT circuit 89.

The variable length encoder 91 assigns codes having an appropriate length to the quantized transform coefficients, respectively, depending on the occurrence frequencies of the quantized transform coefficients. The variable length coding is performed in the order of the zigzag scan, as is shown in Figure 22. The Huffman code which is one of entropy coding is generally used for coding.

In the Huffman coding, data is classified by using two parameters, i.e., the number of successive values of 0, and the following value. A shorter code is assigned to the data with higher occurrence frequency, and a longer code is assigned to the data with lower occurrence frequency. For the Huffman code, a so-called two-dimensional Huffman code is often used. As the result of the variable length coding, the statistic redundancy included in the quantized DCT coefficient is eliminated. It is not necessary to assign the variable length codes to all of the data in the DCT block. In some cases, the variable length code is assigned to part of data in the DCT block, and the fixed length code is assigned to the remaining part of



data. For example, the DC component has no statistical deviation, so that it is processed as being a fixed length. Herein, it is assumed that the DC component has a fixed length. As for the AC components, it is assumed that they are classified into the upper bits of the lower-frequency components and the remaining AC components, and then the variable length coding is performed for the respective components by a unit of each DCT block.

The priority-based classification circuit **92** gives first priorities to the variable length coded data, depending on the positions of the DCT blocks on the screen. The values of the first priorities are preferably set, for example, in such a manner that the highest one is located at the center of the screen and they gradually become lower toward the periphery thereof, as is shown in Figure **25A**. Next, the priority-base classification circuit **92** gives second priorities to the variable length coded data, depending on the coefficients in the DCT block. The values of the second priorities are preferably set, for example, in such a manner that the highest one is given to the upper bits of the DC component, and they become lower in the order of the upper bits of the lower-frequency AC components (zigzag order), the lower bits of the DC component, the lower bits of the lower-frequency AC components (zigzag order), and the remaining AC components (zigzag order), as is shown in Figure **23**. As to the AC components, the variable length coding is performed for the upper bits of the lower-frequency thereof and for the remaining components, respectively, by a unit of each DCT block, so that the priorities are given to the variable length codes.

Figure **26** shows an exemplary determination table for determining the total priorities based on the first and second priorities. The horizontal direction of Figure **26** shows the classification depending on the coefficients in the DCT block based on the second priorities, and the vertical direction of Figure **26** shows the classification depending on the positions of the DCT blocks on the screen based on the first priorities. If the first priorities are used in preference to the second priorities, the total priorities have the order designated by the numerals in Figure **26**. In Figure **26**, the lower numeral indicates the higher priority. The determination rule of the priority is not limited to the rule shown in Figure **26**. Alternatively, the data may be classified in accordance with other criteria, or priorities other than the priorities described given may be given. The values of priority (the second priorities) depending on the positions of DCT blocks on the screen may be set as is shown in Figures **25B** and **25C**. If necessary, any desired position of the screen may be given a higher priority. For example, when a specific screen is to be constructed, a position where a more important

element exists may given a higher priority.

The priority-based classification circuit **92** rearranges the variable length coded data in such a manner that the data having the higher priority is located at a position which is commonly scanned by the reproducing head in all of the cases of three or more reproduction speeds, based on the first and second priorities. In the example shown in Figure **27**, the variable length coded data is rearranged so as to have the order from the lower components to the higher components, and the order from the components corresponding to the DCT block positioned at the center of the screen to the components corresponding to the DCT blocks positioned at the periphery of the screen. In order to simplify the explanation, it is assumed that the priority for the upper bit of a specific component is equal to the priority for the lower bit of the specific component.

The sync block generation circuit **93** divides the data rearranged based on the priorities by the priority-based classification circuit **92** into sync blocks. The term "sync block" means a block as a unit for recording and reproducing. As is shown in Figure **45D**, the recorded track is constituted of sync blocks which is a minimum unit for recording and reproducing. The sync block includes a sync signal **Sync**, **ID** and data which are necessary for recording and reproducing. The sync block **Sync** and **ID** are added to the data by the sync block generating circuit **93**. For example, **ID** includes an identification code indicating the type of data, a position of the data on the screen, a recorded track No. and a sync block No., and is used for the reconstruction of image and the tracking control during the reproduction.

The error correction code adding circuit **68** adds an error correction code to the sync block. Thereafter, the sync block with the error correction code is recorded on the tape-like recording medium **15** via the recording head **60**.

As the scanner used for recording and reproducing, for example as is shown in Figure **20**, a drum **37** having recording heads **41(L)** and **42(R)** and heads **44(R)** and **45(L)** diametrically opposed to the recording heads **41(L)** and **42(R)** can be used. The heads **44(R)** and **45(L)** are used for auxiliary heads dedicated for reproduction and not used for recording. The tape-like recording medium **15** obliquely wraps the scanner having such a construction, so as to perform the helical scan recording.

Figure **14** shows a pattern of recorded tracks on a tape and the head path during the variable-speed reproduction. The reference numerals **1** and **2** denote the tracks recorded by the recording heads **41(L)** and **42(R)**, respectively. The recording heads **41(L)** and **42(R)** have respectively different



recording azimuths, so that the adjacent tracks on the tape are recorded with different azimuths. The arrows in Figure 14 indicate the paths of RL paired heads, or R'L' paired auxiliary heads during the high-speed reproduction. The thinner arrow indicates the head path in the case of x4 speed. The intermediate arrow indicates the head path in the case of x8 speed. The thick arrow indicates the head path in the case of x16 speed. In Figure 14, the portion Y1 is commonly traced by the head in the cases of all the x4, x8 and x16 speeds. The portion Y2 and the portion which is hatched the same as in the portion Y2 are portions which are commonly traced by the head in the cases of x4 and x8 speeds. The portion Y3 and the portion which is hatched the same as in the portion Y3 are portions which are traced by the head in the case of x4 speed. In accordance with the priorities determined by the determination table shown in Figure 26, the data is recorded in the portions Y1, Y2, and Y3 in the order of priority. In this way, the data with higher priority is recorded in the portion which is commonly traced by the head at a lot of speeds, so that it is possible to realize a high-speed reproduction in which an image is reconstructed only by using the data with higher priority. In other words, in the low-speed reproduction, an image including components from lower to higher components can be reproduced. As the reproduction speed becomes higher, it becomes possible to obtain a high-speed reproduced image in which the components of higher frequencies or lower bits or the components corresponding to the screen periphery are gradually reduced.

The signal processing during the recording will be described below in more detail.

As is shown in Figure 45A, the priority-based classification circuit 92 has a high-speed reproduction data separation circuit 129 and a shuffling memory 130. The data input through the terminal 128 is separated into the data for high-speed reproduction and the other data by the high-speed reproduction data separation circuit 129. The data for high-speed reproduction and the other data are input into the shuffling memory 130. The shuffling memory 130 includes, as is shown in Figure 45B, a Y1 buffer 161 for temporarily storing the data for high-speed reproduction corresponding to the portion Y1, a Y2 buffer 162 for temporarily storing the data for high-speed reproduction corresponding to the portion Y2, a Y3 buffer 163 for temporarily storing the data for high-speed reproduction corresponding to the portion Y3, a buffer 164 for temporarily storing the other data corresponding to the portions other than the portions Y1 to Y3, and a selector 165 for selecting one of the outputs of the buffers 161-164. The selector 165 has terminals 1 to 4 which are connected to the outputs of the

buffers 161 to 164, respectively. The data stored in the buffers 161-164 are output by switching the selector 165 at a predetermined timing. The switching timing of the selector 165 will be described below.

The recorded tracks shown in Figure 14 are classified into four types, A, B, C and D, respectively, as is shown in Figure 45C. These four types are periodically recorded onto the tape. In Figure 45C,  $t_0$  indicates the time when the head starts to record data onto each track, and  $t_7$  indicates the time when the head terminates the recording of data.

In the example shown in Figure 45C, track A is a track for recording data other than the data for high-speed reproduction. When the head traces the track A, the selector 165 is controlled so as to always select terminal 4, as is shown in row A in Figure 45E. As a result, the data stored in the buffer 164 other than the data for high-speed reproduction is recorded on track A. Track B is a track for recording the data for high-speed reproduction onto the portion Y3 in the vicinity of the center thereof. When the head traces track B, the selector 165 is controlled so as to select the terminal 4 from time  $t_0$  to time  $t_1$ , as is shown in row B. From time  $t_1$  to time  $t_6$ , the head passes the portion Y3. The selector 165 is controlled so as to select the terminal 3 from time  $t_1$  to time  $t_6$ . As a result, the data for high-speed reproduction stored in the Y3 buffer 163 is recorded onto the portion Y3. The selector 165 is controlled so as to select the terminal 4 again from time  $t_6$  to time  $t_7$ . Track C is a track for recording the data for high-speed reproduction onto the portion Y3 in the vicinity of the center of the track and onto the portion Y2 in the vicinity of the center of the portion Y3, respectively. As is shown in row C, the selector 165 is controlled so as to select the terminal 4 from time  $t_0$  to time  $t_1$  and from time  $t_6$  to time  $t_7$ , to select the terminal 3 from time  $t_1$  to time  $t_2$  and from time  $t_5$  to time  $t_6$ , and to select the terminal 2 from time  $t_2$  to time  $t_5$ . From time  $t_2$  to time  $t_5$ , the head passes the portion Y2. As a result, the data for high-speed reproduction stored in the Y2 buffer 162 is recorded onto the portion Y2. Track D is a track for recording the data for high-speed reproduction onto the portion Y3 in the vicinity of the center of the track, onto the portion Y2 in the vicinity of the center of the portion Y3, and onto the portion Y1 in the vicinity of the center of the portion Y2, respectively. As is shown in a row D in Figure 45E, the selector 165 is controlled so as to select the terminal 4 from time  $t_0$  to time  $t_1$  and from time  $t_6$  to time  $t_7$ , to select the terminal 3 from time  $t_1$  to  $t_2$  and from time  $t_5$  to time  $t_6$ , to select the terminal 2 from time  $t_2$  to time  $t_3$  and from time  $t_4$  to time  $t_5$ , and to select the terminal 1 from time  $t_3$  to time

$t_4$ . The head passes the portion Y1 from time  $t_3$  to time  $t_4$ . As a result, the data for high-speed reproduction stored in the Y1 buffer 161 is recorded onto the portion Y1.

In this way, by switching the selector 165 in the synchronous manner with the types of tracks to be recorded and the position of the recording head, it is possible to realize the recorded pattern shown in Figure 14. It is understood that the recorded pattern shown in Figure 14 is only an exemplary one, and the recorded pattern is not limited to this specific one. It is sufficient to switch the selector 165 at a predetermined timing based on the recorded pattern. By appropriately controlling the switching timing of the selector 165, a desired recorded pattern can be obtained. In the case where there is a time delay from the switching of the selector 165 to the time when the data is actually recorded on the track, it is sufficient to control the switching of the selector 165 at a timing earlier by the time delay.

Next, referring back to Figure 38, the signal processing in the production will be described.

As to the data reproduced by the reproducing head 61, a bit error which may occur in the recording and reproducing is corrected by an error corrector 71. Then, the sync signal which is added for each sync block is removed by the formatter 94, and the data and the ID indicating the contents of the data are supplied to a DCT block reconstruction circuit 95. The process in the DCT block reconstruction circuit 95 is completely reversed from the process of the priority-based classification in the recording. That is, in the DCT block reconstruction circuit 95, the DCT block is reconstructed from respective codes which are dispersed into the sync blocks. As to the codes recovered into the DCT block, the codes which were subjected to the variable length coding in the recording are recovered so as to be the fixed length codes in the variable length code decoder 96. The fixed length codes are subjected to the inverse quantization in an inverse quantizer 97. In the inverse quantization, the value in the quantization table which was used in the recording is multiplied. The inverse quantized codes are finally subjected to the inverse DCT in an inverse DCT circuit 98, and then the reproduced image is obtained at the output terminal 63.

In the reproduction at x1 speed, the image can be reconstructed by using all of data recorded on the tape. In the reproduction at a high speed, the image is reconstructed by using the data which can be reproduced.

As described regarding the tape patterns, the image is reconstructed only by using the data having the higher priority.

It is appreciated that the process of the priority-based classification circuit 92 may be performed prior to the variable length coding as is shown in Figure 39. In such a case, for example, as is shown in Figure 28, the coefficients are classified into component units each having equal frequency after the DCT, and then the variable length coding is performed for each coefficient unit. Accordingly, in the reproduction, the process of the DCT block reconstruction circuit 95 is performed after the process of the variable length code encoder.

The method according to the invention can be applied to any compression for each block unit which is not limited to the compression by using the orthogonal base transform. For example, another compression process such as ADRC (Adaptive Dynamic Range Coding) may be used.

In this example, two types of priorities, i.e., the priority based on the positions in the screen and the priority relating to the importance of the DCT coefficient are used. In the high-speed reproduction, only the data having the higher priority is used, so as to reconstruct the image. Therefore, even when the amount of obtained data is reduced in the high-speed reproduction, an image for one screen can be reconstructed only by using the data in the screen.

It is appreciated that the invention can be applied to any other recording and reproduction in addition to the video signal recording and reproduction by helical scanning. For example, the invention can be applied to the recording and reproduction of a disk.

#### Example 4

Hereinafter, a signal recording and reproducing apparatus in a fourth example according to the invention will be described. Figure 40 shows the construction of the signal recording and reproducing apparatus in the fourth example according to the invention. The signal recording and reproducing apparatus in the fourth example includes, in addition to the construction shown in Figure 38, a block subsampler 99 and a lost block interpolation circuit 100. The same circuits are designated by the same reference numerals as those shown in Figure 38, and the detailed descriptions thereof are omitted.

The digital video signal input through the input terminal 58 is first processed in the DCT circuit 89. The compression process is the same as the compression process in the signal recording and reproducing apparatus in the third example, so that the description thereof is omitted. Herein, the intra-frame compression is used, but alternatively, the inter-frame compression may be used.

The codes which are rearranged depending on the priorities thereof in the priority-based classification circuit 92 are input into the subsampler 99. The subsampler 99 performs the subsampling process by each block unit, for the codes corresponding to predetermined components among the input codes. It is preferable that the predetermined components may include at least the DC component. This is because the DC component is essential for reconstructing an image of one screen. In order to perform the subsampling process by a block unit, it is necessary to previously classify a plurality of blocks which constitute an image of one screen into the predetermined number of groups. For example, as is shown in Figure 29A, the plurality of blocks which constitute an image of one screen are classified into a first group and a second group in checker. Hereinafter, the first group is referred to as group S1 and the second group is referred to as group S2. The group S1 includes hatched blocks and the group S2 includes the other blocks. The subsampler 99 rearranges the codes in such a manner that the codes included in the group S1 and the codes included in the group S2 are recorded in predetermined positions on the tape, respectively, and then outputs the codes.

The thus classified codes are divided into sync blocks by the sync block generation circuit 93. The sync block is a unit for recording and reproducing. Basically, the codes are divided in such a manner that the codes having almost the same priority are included in one and the same sync block, and the codes having different priorities are included in the different sync blocks. In addition, the codes are divided in such a manner that the codes in the group S1 and the codes in the group S2 which are classified by the block subsampler 99 are included in the different sync blocks.

When the codes are divided into sync blocks, the sync block generation circuit 93 adds an ID indicating the type of data in a sync block and a sync signal required for the recording and reproducing.

To each of the codes divided into the sync blocks, an error correction code is added by the error correction code adding circuit 68, so that the codes become the recording signals. The recording signals are recorded onto the tape-like recording medium 15 by using the recording head 60.

For the scanner used for the recording and reproducing, for example, a scanner shown in Figure 20 is used.

The recorded pattern recorded by the signal recording and reproducing apparatus in the fourth example is shown in Figure 14 the same as in the case of the signal recording and reproducing apparatus in the third example. For example, in accordance with the priority determined by the deter-

mination table in Figure 26, the data is recorded onto the portions Y1, Y2, and Y3, in the order of the priority of the data. In this way, by recording the data having the higher priority into the portion which is commonly traced by the head at a large number of speeds, it is possible to realize the high-speed reproduction for reconstructing an image only by using the data having the higher priority. That is, in the low speed reproduction, it is possible to reconstruct an image including all the components from the lower frequency to the higher frequency. As the reproduction speed becomes higher, it is possible to obtain an image in which the components of higher frequencies or lower bits or the components corresponding to the screen periphery are gradually reduced.

Preferably, the DC upper bit component which has the highest priority is recorded on an area having the highest priority. Hereinafter, in which positions of the tracks the DC upper bit component in the group S1 and the DC upper bit component in the group S2 are recorded will be described.

Figures 30A and 30B show exemplary recorded patterns of group S1 and the group S2 which are classified by the block subsampler 99.

In Figure 30A, the data included in the group S1 and the data included in the group S2 are recorded into the area designated by S1 and S2, respectively. As is shown in Figure 29A, two blocks in the group S1 and two blocks in the group S2 constitute one macro block. The area S1 shown in Figures 30A and 30B includes sub-areas S1-1 and S1-2, and the area S2 includes sub-areas S2-1 and S2-2. In each of the sub-areas, data is recorded in the order from the screen center to the screen periphery. In more detail, in the sub-areas S1-2 and S2-1, the data of groups S1 and S2 belonging to the macro block located from the screen center to the left end of the screen are recorded in the directions indicated by arrows, respectively. In the sub-areas S1-1 and S2-2, the data of groups S1 and S2 belonging to the macro block located from the screen center to the right end of the screen are recorded in the directions indicated by arrows, respectively.

Next, the signal processing in the reproduction will be described, referring back to Figure 40.

As to the data reproduced by the reproducing head 61, a bit error which may occur in the recording and reproducing is corrected by an error corrector 71. Then, the sync signal which is added for each sync block is removed by the formatter 94, and the data and the ID indicating the contents of the data are supplied to a DCT block reconstruction circuit 95. The process in the DCT block reconstruction circuit 95 is completely reversed from the process of the priority-based classification in the recording. That is, in the DCT block re-

construction circuit 95, the DCT block is reconstructed from respective codes which are dispersed into the sync blocks. The codes of the DCT blocks are input into the lost block interpolation circuit 100. The lost block interpolation circuit 100 interpolates the data of blocks which are lost in the reproduction. The codes which were subjected to the variable length coding in the recording are recovered so as to be the fixed length codes in the variable length code decoder 96. The fixed length codes are subjected to the inverse quantization in an inverse quantizer 97. In the inverse quantization, the value in the quantization table which was used in the recording is multiplied. The inverse quantized codes are finally subjected to the inverse DCT in an inverse DCT circuit 98, and then the reproduced image is obtained at the output terminal 63.

In the reproduction at x1 speed, the image can be reconstructed by using all of data recorded on the tape. In the reproduction at a high speed, the image is reconstructed by using the data which can be reproduced.

As described regarding the tape patterns, the image is reconstructed only by using the data having the higher priority.

As described above, as the reproduction speed becomes faster, the area obtained per 1 track is reduced.

It is assumed that the area from which the data can be obtained is the area S1 shown in Figure 30A. The data recorded on the area S1 is the data which is obtained by extracting the DC components from every second block, so that the image cannot be constructed directly from the data recorded on the area S1. As is shown in Figure 29B, the DC component recorded on the area S2 (E) which cannot be obtained at the reproduction speed can be obtained by performing the interpolation process based on the DC components in the areas S1 (A, B, C, and D) located around the area E. The lost block interpolation circuit 100 performs the interpolation process. The interpolation is achieved by averaging the DC components recorded in the areas A, B, C, and D, and by setting the averaged component as the DC component of the area E. Alternatively, among the DC components recorded in the areas A, B, C, and D, DC components which are suitable for the interpolation are adaptively selected and averaged, and the averaged component is used for the DC component of the area E.

Alternatively, the component of the area E may be interpolated so that the pixels in the peripheral portion of the area E and the pixels of the areas A, B, C, and D which are externally adjacent to the area E continue smoothly. In this case, it is preferable that the DC component of the area E may be interpolated so that the sum of squares or the sum

of absolute values of differences between the values of the pixels in the peripheral portion of the area E and the values of the pixels of the areas A, B, C, and D which are externally adjacent to the area E becomes minimum. For example, the method of least squares is applied by using the DC component to be interpolated between the values of the pixels in the peripheral portion of the area E and the values of the pixels of the areas A, B, C, and D which are externally adjacent to the area E as the variable, so that the DC component of the area E can be obtained. According to this method, the DC component is obtained as an averaged value of differences between the pixels in the peripheral portion of the area E and the pixels which are externally adjacent to the area E.

Alternatively, instead of the use of the pixels in the peripheral portion of the area E and the pixels which are externally adjacent to the area E, the method of least squares may be applied by using values of intermediate points between the pixels in the peripheral portion of the area E and the pixels which are externally adjacent to the area E which are estimated from the side of the area E, and values of intermediate points therebetween which are estimated from the side of the areas A, B, C, and D, so that the DC components of the area E can be interpolated with higher accuracy. The intermediate points may be estimated by the linear estimation from each side.

As is shown in Figure 30A, in the case where the obtained area is shifted from the area indicated by solid line to the area indicated by broken line due to the tracking error, the data of group S1 recorded in the lower end of the area S1-2 and corresponding to part of image in the vicinity of the screen center cannot be obtained. Instead of the data, the data of group S2 recorded in the lower end of the area S2-1 and corresponding to part of image in the vicinity of the screen center can be obtained.

In this way, even when one subsampling data is lost due to the tracking error, the other subsampling data can be obtained. In this case, it is possible to obtain one of paired blocks which are mutually interpolated among four blocks belonging to one macro block, regardless of the position of the obtained area in the area S1, S2, so that the image can be constructed by interpolation. The image can be constructed in the same way in the arrangement shown in Figure 30B. It is understood that the block subsampled data is not necessarily recorded in the arrangements shown in Figures 30A and 30B. It is sufficient that the data which is lost due to the tracking error and the new obtained data have a relationship in which the data can be mutually interpolated.

According to the signal recording and reproducing apparatus in this example, even if the DC component cannot be obtained up to the half thereof due to the scratch on the tape or the tracking error, the image can be constructed by interpolation. Thus, the apparatus has a high resistance against the scratch and the tracking error. In addition, a reproduction speed which is higher than the conventional one can be selected.

In the above example, the case where the subsampling and the interpolation are performed only for the DC components is described. Alternatively, instead of, or in addition to, the DC components, the subsampling and the interpolation may be performed for the AC components. In the above example, the subsampling is performed in accordance with the classification into the two phases, i.e., the groups **S1** and **S2**. Alternatively, the subsampling may be performed in accordance with the classification into three or more phases, e.g., four phases.

#### Example 5

Hereinafter, a signal recording and reproducing apparatus of a fifth example according to the invention will be described. Figure 41 shows the construction of the signal recording and reproducing apparatus of the fifth example according to the invention.

The process in the recording from the input terminal **58** to the priority-based classification circuit **92** and the process in the reproduction from the DCT block reconstruction circuit **95** to the output terminal **63** are the same as those shown in Figure 38, so that the descriptions thereof are omitted.

Among the output of the priority-based classification circuit **92**, the upper bits of the low-frequency component having the higher priority are recorded in, for example, an area **1** in Figure 15. The other data having the lower priority is recorded in the areas **2** and **3**. At this time, the data recorded in the respective areas are attached with identification codes which are different from each other by a tracking identification code adding circuit **101**. Then, an error correction code is added by the error correction code adding circuit **68**. The identification code added to the data recorded in the area **1** indicates that the reproducing head passes the proper position. The identification codes added to the data recorded in the areas **2** and **3** indicate that the head path is deviated forwardly or backwardly.

The codes indicating the contents of data may also be used as the tracking identification codes. Alternatively, besides the codes indicating the contents of data, the tracking identification codes may

be additionally used.

The rotating drum having recording head is shown in, for example, Figure 19.

The arrows in Figures 15 and 16 indicate the head paths when the high-speed reproduction is performed for the tape-like recording medium having the recorded areas which are described above.

In the case where, in the reproduction, the recording medium is made to travel at a faster speed than in the recording, the head traverses a plurality of tracks. In Figures 15 and 16, a broken-line arrow indicates the case where the head does not pass the area **1** in which the data for high-speed reproduction is recorded (i.e., an off-tracking condition), and a solid-line arrow indicates the case where the head properly passes the area **1** (i.e., an on-tracking condition). When the head is in the off-tracking condition, the head may reproduce the data in the area **2** or **3**. In the area **2** or **3**, the code indicating in which direction the head is deviated is recorded. Thus, the servo can be applied in order that the head becomes into the on-tracking condition for the area **1**. Actually, after the error correction is performed for the reproduced signal by the error correction circuit **71**, the head position is judged based on the identification code by the head position judgment circuit **102**. Then, the servo is applied based on the judged head position.

The servo is usually performed by controlling any of or all of the medium traveling speed, the drum rotation speed, and the head position on the drum.

Figures 31A to 31D show exemplary patterns of identification codes. The identification codes in Figure 31A follow the above-described manner. If an identification code indicating the center of the area **1** is additionally recorded in the center portion of the area **1**, the servo can be applied more accurately. The method is described below.

Figures 32A and 32B are concept diagrams showing the reproduction envelopes during the high-speed reproduction. The reproduction envelope during the high-speed reproduction has a shape in which the amplitude is periodically changed because the head moves so as to traverse a plurality of tracks. When the envelope is the smallest, the head jumps the track. If the head passes the area **1** but does not pass the center of the area **1** during the high-speed reproduction, the center identification code is detected at a position which is deviated from the maximum amplitude position of the envelope, as is shown in Figure 32A. Thus, by examining the relative positional relationship between the amplitude of the envelope and the center identification code, it is possible to judge whether the head passes the center of the area **1** or the edge portion of the area **1**. The amplitude of the envelope may be judged by di-

rectly monitoring the envelope. Alternatively, in order to judge the amplitude of the envelope, there are a method for checking the error rate of the reproduced data, and a method for recording additional codes at positions forward and backward of the center identification code of the area 1. If a portion of the area 1 where head passes can be detected, the head path is controlled by the above-described method, so that the servo can be performed accurately in order that the center identification code positioned at the center of the envelope, as is shown in Figure 32B.

Figures 31B and 31D show the cases where the number of identification areas is increased. Figure 31D shows the case where, instead of applying different identification codes to different areas, identification numbers are sequentially assigned to the tracks from the lower end to the upper end. In the cases shown in Figures 31B and 31D, it is possible to grasp in detail which portion of the track the head passes. Accordingly, it is possible to grasp the distance between the position which is desired to be traced by the head and the current head position, and hence to apply the optimal servo depending on that distance. Figure 31C shows the case where the area 1 is located at a position other than the center portion of the track. Also in the case shown in Figure 31C, the same control as described above can be performed.

The identification codes are described so that the different identification codes are assigned to the same track. However, it is appreciated that the identification codes may also be assigned to respective tracks.

If the rotating drum having two pairs of heads are used as is shown in Figure 20, paired tracks, i.e., two tracks are simultaneously scanned, so that, if the data in one of the paired tracks includes an error and the identification code of the track cannot be obtained, the identification code of the other track can be used. Therefore, this structure has high resistance against data error.

The area capable of being scanned is changed depending on the speed of the medium. As the speed becomes slower, the area increase along the track extending direction. Accordingly, a high-speed reproduction can be realized in which, as the speed becomes slower, an image with a larger amount of information can be reproduced. In this case, the head can be controlled in the same way as described above.

In this example, the data constituting an image during the high-speed reproduction and the other data are attached with different identification codes, and the head path is controlled by using the identification codes, whereby the data of a specific area can be accurately reproduced.

#### Example 6

Hereinafter, a signal recording and reproducing apparatus in a sixth example according to the invention will be described. Figure 42 shows the construction of the signal recording and reproducing apparatus of the sixth example.

In Figure 42, a bit stream 103 is input from the input terminal 58. Then, the bit stream 103 is recorded in a predetermined form on the tape-like recording medium 15, through a bit stream separation circuit 104, an ID adding circuit 105, an ID pointer adding circuit 106, a data shuffler 67, an ECC circuit 68, a recording amplifier 82, and a recording head 60.

An example of the bit stream 103 which is input from the input terminal 58 is shown in Figure 33. In this example, the input bit stream 103 is composed of data 47 processed by intra-frame compression and data 48 processed by inter-frame compression.

The input bit stream 103 is composed of the image data processed by intra-frame compression for one frame at a certain time, and the image data processed by inter-frame compression or intra-frame compression for the successive some frames. The bit stream 103 is first input into the bit stream separation circuit 104. The bit stream separation circuit 104 separates the input bit streams 103 into the image data for variable-speed reproduction and the other image data, and outputs the separated data. The image data for variable-speed reproduction is, for example, the intra-frame compressed data 49. The other image data is, for example, the inter-frame compressed data 50.

The image data for variable-speed reproduction is input into the ID adding circuit 105 where an ID for identifying the data during the reproduction is added. The other image data is input into the ID pointer adding circuit 106 where an ID for identifying the data during the reproduction and a pointer for specifying a position where the data for variable-speed reproduction is located in the original bit stream during the reproduction are added. The output image data from these circuit are the ID added data 51 and the ID pointer added data 52, respectively, as shown in Figure 33. Herein, the reference numerals 53 and 54 indicate the ID code and the pointer, respectively.

Thereafter, the image data for variable-speed reproduction and the other image data are respectively input into the data shuffler 67. Figure 47A shows the construction of the data shuffler 67. As is shown in Figure 47A, the data shuffler 67 includes input terminals 140, 141, memories 142, 143, switches 144, 145, an image data rearrangement circuit 146, and an output terminal 147.

The data shuffler 67 serves to distribute the data onto the recording medium, when the data is to be recorded on the recording medium. For example, the intra-frame compressed data 49 is input through the input terminal 140, and stored in the memory 142. The inter-frame compressed data 50 is input through the input terminal 141, and stored in the memory 143. The data rearrangement circuit 146 controls the open/close of the switches 144 and 145 at predetermined timings, whereby the order of data is rearranged so that the intra-frame compressed data is located on part of or all of the portions of the recording medium which are commonly traced by the reproducing head at a plurality of reproduction speeds. The data rearrangement circuit 146 rearranges the order of data so that the error correction is efficiently performed during the recording and the reproduction.

Next, to the data in which the order thereof is rearranged, an error correction code is added in the ECC circuit 68. The data is then amplified by the recording amplification 82, and recorded onto the tape-like recording medium 15 by the recording head 60.

The signal recording and reproducing apparatus further includes a reproducing head 61, a reproducing amplifier 83, an ECC circuit 71, a data deshuffler 72, and a bit stream reconstruction circuit 107, whereby the reproduced bit stream 108 is output from the output terminal 63.

During the normal reproduction, the signals are read out from the respective recorded tracks by using the reproducing head 61 (the recording head 60 may also function as the reproducing head), and the read signals are amplified by the reproducing amplifier 83 and input into the ECC circuit 71. Any errors which occur during the recording and reproduction in the signals input into the ECC circuit 71 are possibly corrected, and then fed to the data deshuffler 72.

Figure 47B shows the construction of the data deshuffler 72. As is shown in Figure 47B, the data deshuffler 72 includes an input terminal 148, a memory 149, an image data separation circuit 150, data rearrangement circuits 151, 152, and output terminals 153, 154.

The signal input through the input terminal 148 is temporarily stored in the memory 149. Next, the image data separation circuit 150 appropriately reads out the reproduced image data from the memory 149, and separates the reproduced image data into the original intra-frame compressed image data and inter-frame compressed image data. The operation of the circuit 150 is reversed from the operation during the recording. The order of the separated data are rearranged into the original one by the data rearrangement circuits 151 and 152, respectively. The operations in the data rearran-

gement circuits 151 and 152 are completely reversed from the rearrangement by the data shuffler 67 in the recording. The rearranged data are separately output from the output terminals 153 and 154.

The intra-frame compressed image data and the inter-frame compressed image data output from the data deshuffler 72 are respectively input into the bit stream reconstruction circuit 107, so as to reproduce the original bit stream.

In the variable-speed reproduction, the tape is made to travel at a speed different from the normal speed, so that the reproducing head obliquely scans the recorded tracks, and hence it is not possible to reproduce all of the image data. However, by reproducing the intra-frame compressed image data which is separated from the input bit stream and located at a particular position based on the operation of the data shuffler 67, it becomes possible to obtain an image for the variable-speed reproduction.

The data for variable-speed reproduction may be part of the intra-frame compressed data, as described above.

As in the sixth example, the compressed bit stream which is transmitted in the broadcasting may be directly separated into the data for variable-speed reproduction and the other data.

#### Example 7

Hereinafter, a signal recording and reproducing apparatus of a seventh example according to the invention will be described. Figure 43 shows the construction of the signal recording and reproducing apparatus of the seventh example.

First, the format of the signal input into the signal recording and reproducing apparatus is described.

Figure 34 shows the concept of the spectrum of a modulated wave in the transmission band of AD-HDTV system which is proposed in the advanced high definition television system in the U.S.A. In Figure 34, the reference numeral 55 denotes the transmission band, 56 denotes the modulated wave of image data of low-frequency component having the high priority (HP: High Priority), and 57 denotes the modulated wave of the high-frequency component which is added for the high definition image having the priority lower than the aforementioned image data (SP: Standard Priority). In this system, the image data having the higher priority is transmitted by the modulated wave with a higher power. Accordingly, even in the peripheral region of the broadcasting area to which the radio wave is difficult to reach, it is advantageously possible to obtain an image quality to some extent by receiving only the image data of low-frequency



component having the higher priority.

Alternatively, in the DSC-HDTV system which is also proposed in the U.S.A., in the transmission band having a certain band width, the fundamental image data of low-frequency component having the higher priority is modulated by the modulation method for facilitating the reach of radio wave, and the image data of high-frequency component is modulated by another modulation method in which the transmission rate is high but the radio wave is difficult to reach. The thus modulated two types of signals are transmitted by time division duplex.

The two types of image data having a different priority are input through two input terminals **109** and **110**.

To the input terminal **109**, the image data of low-frequency component having the higher priority is input. To the input terminal **110**, the image data having the lower priority than the data input to the input terminal **109** is input. In this example, as is shown in Figure **43**, the signal recording and reproducing apparatus has two input terminals. Alternatively, the signal recording and reproducing apparatus may have one or more input terminals and image data having different priorities may be input to the respective one or more input terminals. Alternatively, different types of image data having different priorities may be input to one and the same input terminal.

The ID adding circuits **111** and **112** add ID's indicating the data type, the position on screen, and the like to the respective image data. The ID added data are encoded into recording codes in the encoders **113** and **114**, respectively. Thereafter, the recording codes are input into the data shuffler **67** where the order of data is rearranged.

The remaining recording process after the data shuffler **67** and the reproduction process before the data deshuffler **72** are the same as those implemented by the circuits shown in Figure **42**.

The output signals from the data deshuffler **72** are decoded by the decoders **115** and **116**, and output from the output terminals **117** and **118** as the output of the reproduction system in the same form as that of the input normal broadcasting signal. As the result of the decoding into the same form as the of the input normal broadcasting signal, the reproduced image can be obtained.

As described above, the data previously having the priority is input, and the data having the higher priority is used as the data for high-speed reproduction.

The portion into which the data for high-speed reproduction is recorded is desirably in the vicinity of the center of the track for the following reasons.

Figure **18** shows the concept illustrating the reproduced envelope. The reference numeral **40** shows the reproduced envelope in the case where

the tape is made to travel at a predetermined speed for recording and reproduction. As is seen from the reproduced envelope **40**, the reproduced output is slightly lowered at both ends of the tape.

The reference numeral **41** shows the reproduced envelope in the case where the tape is made to travel at a higher speed for recording and reproduction. During the high-speed traveling of the tape, the reproduced output at both ends of the tape is lowered as compared with the case of the slower traveling speed.

Therefore, it is desirable that the data for high-speed reproduction is recorded in the vicinity of the center of the tape.

#### Example 8

Hereinafter, a signal recording and reproducing apparatus of an eighth example according to the invention will be described.

Figure **48** shows the construction of a digital VTR according to the invention. In Figure **48**, the digital VTR includes a rotating drum (drum) **502** with magnetic heads (heads) **503a** and **503b** having azimuth angles different from each other, a capstan **505**, a capstan motor **504**, a pinch roller **506**, a rotation speed detector **507**, a capstan motor driver **508**, a drum motor controller **509**, a head amplifier **510**, a demodulator **511**, an ID detector **512**, a tracking error detector **513**, a sampler **514**, a tracking controller **515**, and a pulse generator **516**. The ID detector **512** is used to detect a portion to be reproduced on a magnetic tape **501**. The heads **503a** and **503b** are mounted on the drum **502** in such a manner they are diametrically opposed. The tracking controller **515**, the capstan motor driver **508**, the capstan motor **504**, the capstan **505**, the pinch roller **506**, and the rotation speed detector **507** are used for a tracking control. The operation of the digital VTR having the above-described construction will be described below with reference to Figure **49**.

Figure **49A** shows a recorded pattern of tracks on the tape **501**. In this example, video signals of 10 video frames are subjected to the information compression into one unit, and recorded as one data frame. Among the video signals of 10 video frames, the video signals of 9 video frames are subjected to the interframe compression, and the video signals of the remaining one video frame are subjected to the intra-frame compression. The two types of compressed data are modulated as required and then separately recorded as 10 tracks on the tape. Figure **49A** shows only two data frames. Actually, each track is recorded at a large inclination with respect to the tape **501**. However, in Figure **49A**, for the explanation based on the time sequence, each track is shown at a small inclina-



tion. A series of circulated numbers from 0 to 9 shown at the upper end of the tape indicate the track numbers in the data frame. The tracks having even track numbers have the same azimuth as that of the head **503a** and the tracks having odd track numbers have the same azimuth as that of the head **503b**. Figure **50** shows the data structure in each track. Each track is divided into sub-blocks which are referred to as sync blocks, as is shown in Figure **50(a)**. In the leading portion of each sync block, a sync pattern indicating the start of the sync block is recorded as is shown in Figure **50(b)**. Following the sync pattern, an ID (identification code) which is address information of the sync block and an ID parity for detecting an error of ID are recorded. Then, the digital video signals are recorded. The ID information portion includes the data frame number, the track number and the sync block number as is shown in Figure **50(c)**.

The symbols **f0**, **f1**, **f0**, and **f2** shown at the lower end of the tape **501** indicate the types of pilot signals for tracking control. For the pilot signals **f1** and **f2**, relatively lower but different frequencies which can be separated from the digital information signals and which is difficult to be influenced by the azimuth loss are selected. In the track indicated by **f0**, the pilot signal is not recorded. The respective pilot signals are recorded substantially all over the tracks by frequency duplex with the digital video signals which is similar to that in the 8 mm VTR, or by bit modulation as disclosed in European Patent Application Publication No. 339724.

First, the normal reproduction (the x1 speed reproduction) is briefly described. The tracking controller **515** conveys the tape **501** at substantially the same speed as in the recording, using the capstan motor driver **508**, the capstan motor **504**, the capstan **505** and the pinch roller **506**. The drum motor controller **509** controls the rotation of the drum **502** at a predetermined rotation speed. In the period in which the head **503a** reproduces the tracks, the tracking error detector **513** compares the magnitudes of the pilot signals **f1** and **f2** leaking into the reproduced signals **601**, and outputs a tracking error signal **604** indicating the deviation of the head from the tracks. The tracking controller **515** performs the tracking control by adjusting the tape traveling speed based on the tracking error signal **604** so that the head **503a** scans the track on which the pilot signal **f0** is recorded, and the head **503b** scans the track on which the pilot signal **f1** or **f2** is recorded. The normal reproduction operation is briefly described above, but the detailed description thereof is omitted.

The operation in the reproduction at a speed different from that of the recording, e.g., in the high-speed reproduction is described. The drum **502** is controlled so as to rotate at a predetermined

rotation speed by the drum motor controller **509**. At this time, the drum motor controller **509** detects the rotational position of the drum **502**, and outputs an identification signal (HSW signal) **606** indicating which head is in contact with the tape **501**. The tape **501** is wrapped on the drum **502** by 180 degrees. The tape **501** is sandwiched between the capstan **505** and the pinch roller **506**. Accordingly, the tape **501** travels along the lengthwise direction thereof by means of the rotation of the capstan motor **504**. The tracking controller **515** receives an FG signal **607** from the rotation speed detector **507**, and controls the rotation speed of the capstan motor **504** via the capstan motor driver **508**. The heads **503a** and **503b** mounted on the drum **502** scan the tape **501** by tracing the paths determined by the cylinder rotation and the tape traveling speed. Now, it is assumed that the tape **501** is made to travel at a speed which is 5 times as fast as the normal reproduction speed, and the drum **502** rotates at the same speed as the normal reproduction speed. The scanning paths are indicated by arrows of solid line and broken line on the tape **501** in Figure **49A**. The solid line indicates the path of the head **503a** and the broken line indicates the path of the head **503b**.

The reproduced signals obtained from the respective heads by successively traversing the tracks are head-switched in the head amplifier **510** based on the HSW signal **606**, and amplified. Then, the reproduced signals are supplied to the demodulator **511**, the ID detector **512** and the tracking error detector **513**. The demodulator **511** demodulates and decompresses the reproduced signals successively obtained from all of the tracks in the normal reproduction, so as to substantially perfectly reconstruct the recorded video signals. The reconstructed signals are output as the reproduced video signals **602**. In the high-speed reproduction, the head reproduces the signals by traversing the tracks, so that only the portions forward and backward of an intersecting point where the center of a track having the same azimuth as that of the head scanning path intersects the head scanning path can be reproduced. Such portions may be the hatched portions in Figure **49A**. The demodulator **511** constitutes the image based on the partial information obtained in such a condition, and outputs the image.

When the compressed data is to be decompressed, data of all units used for the compression are required. In this example, the intra-frame compressed data of 1 video frame is smaller in compression unit than the data of the other 9 video frames. Therefore, if the sync block in which the intra-frame compressed data of 1 video frame is selectively reproduced, the image reproduction can be efficiently performed in the high-speed repro-

duction.

In another example, the video signal is divided into a low-frequency component and a high-frequency component, and the components are separately recorded onto different sync blocks. By selectively reproducing the sync block in which the low-frequency component is recorded, the image reproduction can be efficiently performed.

As explained above, in the signal recording and reproducing apparatus, it is often required that a specific part of the recorded data on the tape is selectively reproduced during the high-speed reproduction. That is, it is necessary to lock the phase relationship between the head path and the recorded data. The phase lock operation is next described.

The tracking error detector **513** has, for example, a construction shown in Figure **51**. From the reproduced signal **601**, the pilot signals **f1** and **f2** are extracted by band pass filters **521** and **522**, respectively. The amplitudes of the pilot signals **f1** and **f2** are detected by envelope detectors **523** and **524**, respectively. Then a difference in amplitude ( $f1 - f2$ ) is calculated by a difference calculator **525**, and then output as the tracking error signal **604**.

In the case of the scanning paths shown in Figure **49A**, the tracking error signal **604** during the high-speed reproduction is shown in Figure **49C**. The tracking error signal can be obtained during the reproduction by the head **503b**, but the tracking error signal is not used in this description, so that it is indicated by a broken line. It is assumed that a sync block to be reproduced is located at the hatched portion in Figure **49A**. Figure **49** shows the state where the scanning path just passes on the sync block. In this state, the tracking error signal is 0 at the timing of the reproduction for the sync block. Thus, by controlling the tape travel so that the tracking error signal becomes 0 at this timing, the scanning path can be always fixed on the sync block, as shown in Figure **49A**.

The ID detector **512** and the pulse generator **516** detect the timing at which the tracking error signal is set to be 0. The ID detector **512** detects the ID portion included in each sync block in the reproduced signal **601**. The specific construction is omitted, but for example, an operation such as equalizing, level regeneration, timing regeneration by a PLL (phase locked loop), and the like is performed for the reproduced signal **601** so that the reproduced signal is made to be a digital data series, and then the sync pattern shown in Figure **50(b)** is detected, and the ID portion which follows the sync pattern is extracted. In addition, the error detection is performed for the ID portion by using the ID parity, and only the ID information with no error is output. Note that the function of ID detection is generally provided for the demodulator **511**.

In such a case, the ID information from the demodulator **511** is supplied to the pulse generator **512**.

The track number and sync block number **603** among the ID information is input into the pulse generator **516**. The pulse generator **516** outputs a sample pulse **610** when the ID of the sync block which is currently required to be reproduced, e.g., the sync block indicated in Figure **49A** is detected. An exemplary sample pulse **610** is shown in Figure **49B**. There may be a case where successive plural sync blocks are actually required to be reproduced. For example, in the case where 1 track is constituted of 100 sync blocks, each hatched portion in Figure **49A** includes several sync blocks to a dozen sync blocks. In such a case, the target scanning path is determined to intersect the region occupied by the sync blocks in the vicinity of the center of the region along the track direction, and the pulse generator **516** may detect the sync block positioned at the intersecting position where the scanning path intersects the track center. Alternatively, the scanning path is determined in the same way, and one or more ID's of these sync blocks are detected, whereby the pulse generator **516** outputs the sample pulse **610** at the timing when the scanning path may intersect the track center.

The sample pulse **610** and the tracking error signal **604** are input into the sampler **514**. The sampler **514** samples the tracking error signal at the timing of the sample pulse, and holds the value until the next sample pulse is applied. When the next sample pulse is applied, the sampler **514** outputs the value.

The tracking controller **515** controls the rotation of the capstan so that the sampled tracking error signal **605** becomes 0. In the cases where the phase relationship between the head scanning path and the track pattern on the tape is nearly equal to the ideal state shown in Figure **49A**, the above-described method is sufficient for the control. However, in the cases where the phase relationship is largely different from the ideal state, e.g., in the case where the scanning paths of the head **503a** and **503b** are exchanged, the target sync block is not reproduced. Accordingly, there occurs a vicious cycle in which the ID is not detected, and hence the sample pulse is not generated, therefore the tracking controller **515** cannot operate. In this case, it is necessary to prepare a countermeasure for leading the deadlock state into the proper state of tracking control.

Figure **52** shows an exemplary construction of the tracking controller **515** considering such a counter-measure. In Figure **52**, the tracking controller **515** includes D-type flip-flops **531** and **532**, a latch **533**, switches **534** and **535**, a polarity inversion circuit **536** (an amplifier having a gain of -1), a

voltage source 537, a frequency comparator 538, a reference signal generator 539, an adder 540, and a filter 541. First, the operation of the judgment circuit 542 enclosed by a broken line is described with reference to Figure 53. In Figure 53, the same signals are designated by the same reference numerals as those shown in Figure 52. The judgment circuit 542 judges whether the ID corresponding to the target sync block is detected for each scanning of the head 503a. Now, it is assumed that, during the scanning of the tape by the head 503a, the drum motor controller 509 outputs "H" (high level) as the HSW signal 606. The D-type flip-flop 531 latches the "H" at the D input at the rising edge of the HSW signal and outputs it. In Figure 53, when the sample pulse 610 is applied during the scanning period, e.g., in the first period of the HSW, the D-type flip-flop 531 is reset at this timing and the output thereof becomes to be "L" (low level). If the sample pulse 610 is not supplied as in the second period, the D-type flip-flop 531 is not reset, so that the output thereof remains to be "H". Accordingly, at the falling edge of the HSW signal 606, the output 611 of the D-type flip-flop 531 is latched by the next D-type flip-flop 532, so that a signal depending on the presence or absence of the sample pulse can be obtained in each scanning period as the output 612 of the D-type flip-flop 532.

The polarity of the sampled tracking error signal 605 is inverted in the polarity inversion circuit 536. The inversion or non-inversion of the signal 605 is selected by the switch 534. As is seen from Figure 49B, the polarity of the tracking error signal at the sample pulse position for the even frame is inverted from that at the sample pulse position for the odd frame. Specifically, the tracking error when the scanning path is deviated in a certain direction is inverted between the even frame and the odd frame. This is because the number of tracks constituting one frame is not the integer multiple of the number of tracks in a cycle of tracking pilot frequencies which vary for each track (in this example, four tracks of  $f_0$ ,  $f_1$ ,  $f_0$  and  $f_2$ ). In order to fix the polarity of the tracking error signal used for the tracking control, it is necessary to switch the polarity between the inversion and the non-inversion depending on the even or odd frame of the sampled tracking error signal. At the D input of the latch 533, the least significant bit of the frame number from the ID detector 512, i.e., a frame even/odd signal 608 is input. When the target ID is detected and the sample pulse 610 is applied to the E input, the latch 533 latches the level of the D input and holds the value until the next sample pulse is applied. The switch 534 operates depending on the output 617, so that the polarity of the tracking error signal after the switching is constant.

Next, the switch 535 selects one of the reference voltage from the reference voltage source 537 and the tracking error signal 613 depending on the output 612 of the judgment circuit 542.

In the state where the sample pulse is applied for each scanning, the signal 612 becomes "L" and the switch 535 selects the tracking error signal 613. The output 614 of the switch 535 is supplied to the adder 540. From the speed detector 507 of the capstan motor 504, the FG signal 607 having a frequency depending on the rotation speed of the capstan 505 is applied. The frequency comparator 538 compares the frequency of the FG signal 607 with the frequency of the reference signal applied from the reference signal generator 539, so as to output a speed error signal 615 in accordance with the deviation from the target rotation speed of the capstan motor. The speed error signal 615 and the tracking error signal 614 are added to each other in the adder 540, and subjected to the frequency compensation such as integration compensation in the filter 541, thereby being output as the capstan driving signal 609 to the capstan motor driver 508. The capstan motor driver 508 drives the capstan motor 504 in accordance with the capstan driving signal 609. In this way, the tape travel is adjusted so that the sampled tracking error 605 becomes 0.

In the state where the head scanning position is largely different from the state shown in Figure 49A and hence the sample pulse 610 cannot be obtained, the reference voltage is selected by the switch 535. The reference voltage is added to the speed error signal 615 by the adder 540, and the tape travel is adjusted so that the added signal 616 becomes 0. In this case, the signal 614 keeps the constant value, so that the added signal becomes 0 by offsetting the speed error signal in the reverse direction in DC by the amount equal to the value, thereby being balanced. That is, the tape travel is controlled to be the speed which is deviated by the amount depending on the reference voltage. Therefore, by selecting the reference voltage so that the tape speed in the high-speed reproduction is deviated from the target tape speed by a slight amount, e.g., by about 1%, the phase of the head scanning gradually changes with respect to the data frames. After a while, the scanning path substantially reaches the phase shown in Figure 49A, so that the sample pulse can be obtained. As a result, the switch 535 is switched so as to start the tracking control, and the scanning path is locked to the desired phase. According to the above-described operation, even in the case where the scanning path is largely different from the target path, the phase shifting can be smoothly performed without arising the vicious cycle.

As described above, according to this example, in the case where the reproduction is performed at

a tape speed different from that in the recording, the ID detector detects the ID information included in the reproduced signal, and the pulse generator generates a sample pulse at a timing at which a specific position in a data frame is reproduced based on the detected ID information. The sampler samples the tracking error signal which is detected from the reproduced signal by the tracking error detector at the timing of sample pulse. Thus, the tracking controller operates based on the sampled tracking error signal, whereby the tape speed is adjusted. Accordingly, it is possible to accurately fix the head scanning path at a specific phase on the tape. In the case where the ID is not detected, the tape speed is set to be different from the target speed at which the phase of the head scanning can be locked, so that the phase can be shifted to the phase at which the ID is smoothly detected.

In this example, the case where one data frame is divided into 10 tracks and the tape speed is set to be x5 speed is described. Alternatively, as far as the phase relationship between the head scanning and the data frame can be fixed, the invention can be applied. For example, to the reproduction at a tape speed of integer multiple other than the x1 speed, the invention can be applied (in some cases, in order to fix the relative speed of the head to the tracks, there may accurately occur some deviation from the integer-multiple speed relative to the x1 speed).

The example where two types of pilot signals are recorded on the tape is shown, but the method is not limited to this. As far as the positional relationship between the head and the tracks can be detected in the vicinity of the sync block from which the data is to be selectively read out, the recording method is not limited to any specific one.

Regarding the head construction on the drum, and the wrapping angle of the tape, they are not limited to those shown in this example. Alternatively, two heads may be mounted adjacently, or two or more heads may be mounted.

The example where one sample pulse is generated for one scanning is shown, but the method is not limited to this. Regarding the timing of the sample pulse, it is sufficient that the target scanning path intersects the track having the same azimuth. Thus, a plurality of samplings can be performed. In view of the polarity of the obtained sample value, the number of sample pulses can be increased as the result of the obvious extension, whereby the phase lock accuracy can be enhanced.

The example where the tracking control is performed by the tape speed adjusting which uses the capstan is shown. Alternatively, another method can be used. For example, a method (DTF) in which the head is directly driven to adjust the

tracking can be used.

It is appreciated that the respective components can be implemented by various method as far as the functions equivalent to those described above can be realized. In this example, each block is constructed mainly in hardware. Alternatively, it can be implemented in software having the equivalent function.

#### Example 9

Next, a signal recording and reproducing apparatus in a ninth example of the invention will be described. Figure 54 shows the construction of the digital VTR based on the invention. In Figure 54, except for a delayed pulse generator 517, a timing corrector 518, and a tracking controller 515, the elements have the same constructions and the operations as those in the example shown in Figure 48, so that they are generally described.

Hereinafter, the high-speed reproduction is described mainly considering the differences from the example shown in Figure 48. Tape 501 is made to travel at a tape speed which is about 5 times as fast as the normal reproduction speed, by the capstan 505 which rotates by means of the capstan motor driver 508. Accordingly, the angular relationship between the head scanning path and the tracks is the same as shown in Figure 49A. The arrangement of pilot signals and the data structure in each track are the same as those shown in Figures 49A and 50. The drum 502 is controlled to rotate at a predetermined rotation speed by the drum motor controller 509. The outputs of the heads 503a and 503b are amplified by the head amplifier 510 and head-switched, and then input into the demodulator 511, the ID detector 512, and the tracking error detector 513. The demodulator 511 demodulates the reproduced signals which are intermittently obtained, and outputs the reproduced video signals 602. The ID detector 512 detects and outputs the ID portions in each sync block in the reproduced signals. The tracking error detector 513 detects and outputs the tracking error signal 604 corresponding to the deviation of the head from the track based on the pilot signal amplitude included in the reproduced signals.

The first difference from the example shown in Figure 48 is in that the sampling in the sampler 514 is performed at the timing which is synchronized with the HSW signal. Another difference resides in that the timing corrector 518 finally corrects the scanning path to the target phase by correcting the sample timing. The correction of the timing is performed based on the ID information detected from the reproduced signals. Hereinafter, the operation thereof will be described.

Figure 55 shows the construction of the delayed pulse generator 517, the sampler 514, the timing corrector 518 and the tracking controller 515. In Figure 55, the HSW signal 606 is supplied to a timer 551, a microprocessor 552, the delayed pulse generator 517. The delayed pulse generator 517 outputs a sample pulse 622 after a time period depending on the timing data 621 applied from the microprocessor 552, following the rising edge of the HSW signal 606, has elapsed. The timing data 621 is generated from the output 631 of the timer 551, the track number and sync block number 603 and the HSW signal 606. The generation method is described later. The sampler 514 samples the tracking error signal 604 in accordance with the sample pulse 622, and holds and outputs the sampled value. After the polarity of the sampled tracking error signal 605 is inverted so as to keep the control polarity constant by the inversion circuit 536 and the switch 534 in accordance with the switching signal 635, the sampled tracking error signal 605 is supplied to the adder 540. Thereafter, the speed error signal 615 is generated by the frequency comparator 538 and the reference signal generator 539. The speed error signal 615 is added to the tracking error signal 613, and then supplied to the capstan motor driver 508 through the filter 541. The above operation is the same as in the example shown in Figure 52. As a result, the tape traveling speed is adjusted so that the tracking error signal 605 which is successively sampled by the sampler 514 becomes 0.

Next, the generation of the timing data 621, i.e., the operation for correcting the sample timing is described. The timer 551 is implemented by a counter into which the HSW signal 606 is input. The counter is reset at the rising edge of the HSW signal 606, and thereafter increments the contents at a regular interval. The counter contents of the timer 551 are output as the elapsed time data 631. The elapsed time data 631 indicate the elapsed time which is counted from the rising edge of the HSW signal, and the data 631 is supplied to the microprocessor 552. Figure 56 shows the flowchart illustrating the outline of the program executed by the microprocessor 552. In Figure 56, the symbols  $x$ ,  $y$ ,  $f\_det$ , and  $cnt\_ng$  denote memories contained in the microprocessor 552. The symbols  $X$ ,  $Z$ ,  $HSW$  denote input ports, and  $Y$  denotes an output port. These ports are connected to the elapsed time data 631, the track number and sync block number 603, the HSW signal 606, and the timing data 621, respectively. In Figure 56,  $y_0$ ,  $IDn$ ,  $y_{max1}$ ,  $y_{max2}$ ,  $\Delta y$ , and  $C_{max}$  are constants. The program operation is executed in the following manner.

First, in step 561, the memories and the ports are initialized. The constant  $y_0$  is time data cor-

responding to the time interval from the rising edge of the HSW signal (Figure 49D) to the ideal sample pulse timing (Figure 49B), i.e., in the case where the head scanning path coincides with the target phase. The time data  $y_0$  is output to the output port  $Y$ . The value at the output port  $Y$  is supplied to the delayed pulse generator 517 as the timing data 621. The delayed pulse generator 517 actually generates a sample pulse at the timing shown in Figure 49B. In the initialized state, the tracking control is performed so that the tracking error signal 605 becomes 0 at the timing. In step 575, the pull-in and the setting of the tracking control is waited. Specifically, the program merely waits for the time period corresponding to the response time of the tracking control. In this time period, the tracking pull-in is performed.

Next, in step 562, the detection of the rising edge of  $HSW$  is waited. In step 563, the ID detection flag  $f\_det$  is cleared. In step 564, the values at the input port  $Z$ , i.e., the numbers of track and sync block which are currently reproduced are compared with a predetermined value  $IDn$ . The predetermined value  $IDn$  is a value corresponding to the target sync block among the hatched portions shown in Figure 49A. As the result of the comparison, if the values are matched with each other, this means that the reproduction can be performed to the target sync block. In step 570, the elapsed time data 631 from the timer is input through the input port  $X$  and stored in the memory  $x$ . In step 571, the detection flag  $f\_det$  is set to be 1, and the program proceeds to step 565. If the values are not matched as the result of the comparison at step 564, the program merely proceeds to step 565. If the falling edge of  $HSW$  is detected at step 565, the process proceeds to step 566. Otherwise, the process returns to step 564. In other words, steps 564, 570, 571, and 565 are repeatedly executed during the "H" period of the HSW signal 606.

When the falling edge of  $HSW$  is detected, the program proceeds to step 566. In the case where the detection flag  $f\_det$  is 1, i.e., when the predetermined value  $IDn$  is detected during the "H" period of  $HSW$  (during the immediately preceding scanning period of the head 503a), the elapsed time data stored in the memory  $x$  is transferred to the memory  $y$  in step 567. Then, in step 568, the contents of the memory  $y$  is output to the output port  $Y$ , so that the sample timing is corrected from the initial value  $y_0$  to the timing at which the predetermined value  $IDn$  is detected. Herein, it is assumed that the elapsed time data 631 obtained from the timer 551 and the timing data 621 supplied to the delayed pulse generator 517 have the same unit. Accordingly, the phase of the scanning path determined by the initial timing of the refer-

ence HSW is corrected to an accurate phase excluding error factors such as tracking error.

If the detection flag **f\_det** is 0 in step 566, this means that the value **IDn** was not detected in the immediately preceding scanning period. In such a case, the contents of the memory **cnt\_ng** are incremented in step 576, and then compared with the constant **Cmax** in step 577. If **cnt\_ng** > **Cmax**, the contents of the memory **cnt\_ng** are reset to be 0 in step 578. The process in steps 576 to 578 is provided for the case where the actual scanning path is largely different from the ideal one shown in Figure 49A. If the control polarity is neglected, the phase of scanning path in which the tracking error signal becomes 0 at the timing of **y0** may exist on every second track. Therefore, at the time when the tracking control is pulled in step 575, it is not known into which phase the control is pulled. Thus, in the case where the control is pulled into the shifted phase, it is necessary to correct the locked phase to the target phase. However, even in a condition where the scanning path is close to the target, there may occur a case where the detection of **IDn** fails depending on the state of the reproduced signals. Accordingly, when the detection of **IDn** is successively failed **Cmax** times in the scanning period of the head 503a, i.e., when **cnt\_ng** ≥ **Cmax** in step 577, it is judged that the scanning path is locked to the phase which is different from the target phase, so that the operation for correcting the locked phase is performed. The correction operation is realized by the process of steps 572, 573, and 574.

As the methods for correcting the locked phase, there are various methods. Herein, a method in which the locked phase is gradually shifted by shifting the sample timing is employed. In step 572, the value in the memory **y** is incremented by  $\Delta y$  which is the time-width data for shifting the sample timing every one rotation of cylinder. The time-width data is selected so as to perform the shifting rapidly in the range capable of being followed by the tracking control, depending on the linear operation range of the tracking control system. Next, in step 573, the contents of the memory **y** is compared with the data **ymax1**. The data **ymax1** is the time data corresponding to one scanning period. When the contents of the memory **y** is increased by every rotation of the cylinder in step 572, the sample timing will exceed the scanning period. In order to prevent this, the sample timing is somewhat recovered by subtracting **ymax2** from **y**. However, in order not to disturb the tracking control or not to recover the phase of the head scanning path to the original one, the subtracting time amount is set to correspond to the cyclic period of the pilot signal frequency, i.e., the time period for which the head traverses four tracks. In

this example, the head traverses four tracks in one scanning period, so that the value **ymax2** is equal to the time of one scanning period. That is, **ymax2** = **ymax1**. As the result of such selection, the sample value of the same tracking error signal can be obtained, even if the sample timing is discontinuously changed. Accordingly, while the tracking control is set in the locked state, the head scanning path can be continuously shifted. By outputting the value of **y** set in step 567 or 574 to the output port **Y** in step 568, the elapsed time data 621 is fed to the delayed pulse generator 617. As the result of the above process, the head scanning path is gradually shifted by every rotation of a cylinder. When the head scanning path finally reaches the vicinity of the target phase, **IDn** is detected, so that the sample timing is corrected in steps 570, 571, and 567. Thus, the scanning path can be accurately controlled to the target scanning path phase.

If **cnt\_ng** < **Cmax** in step 577, the process proceeds to step 568. Since the value of **y** remains unchanged, the sampling is performed at the sample timing which was previously set.

The process of step 569 is not executed by the timing corrector 518, but executed by the tracking controller 515. That is, the process is required because the number of tracks in one data frame (ten in this example) is not the integer multiple of the number of tracks in a cyclic period of pilot signal frequency (four in this example). In step 569, the polarity of the sampled tracking error signal 605 which is inverted every data frame is made to be constant for the use in the control. The polarity of the value **P** at the output port is inverted every rotation of cylinder. In this example, the tape travels by 1 data frame as the result of one cylinder rotation, i.e., two head scanings. Thus, the polarity of the tracking error signal is inverted depending on the inversion, thereby achieving the polarity matching. Specifically, after the timing of the output signal 633 is matched with the sample timing at the D-type flip-flop 553, the signal 633 is supplied to the switch 534 which selects the inversion or non-inversion of the tracking error signal.

Thereafter, the program returns to step 562, and the foregoing steps are repeated.

As described above, according to this example, when the reproduction is performed at a tape speed which is different from that in the recording, the delayed pulse generator generates a sample pulse at a timing synchronized with the rotation of cylinder. The sampler samples the tracking error signal in accordance with the sample pulse. The tracking controller operates based on the sampled tracking error signal, so as to adjust the tape traveling. During the operation, the ID detector detects the ID information included in the reproduced sig-

nals. The timing corrector corrects the sample pulse generation timing of the delayed pulse generator based on the detected ID information. Accordingly, the head scanning path can be accurately fixed to the specific phase. In the case where the scanning path is locked at a phase other than the target phase, the timing corrector moves the locked phase by gradually changing the sample pulse generation timing. Accordingly, the phase can certainly be pulled into the target phase.

In this example, the case where one data frame is divided into 10 tracks and the tape speed is set to be x5 speed is described. Alternatively, as far as the phase relationship between the head scanning and the data frame can be fixed, the invention can be applied. For example, to the reproduction at a tape speed of integer multiple other than the x1 speed, the invention can be applied (in some cases, in order to fix the relative speed of the head to the tracks, there may occur some deviation from the integer multiple speed relative to the x1 speed).

The example where two types of pilot signals are recorded on the tape is shown, but the method is not limited to this. As far as the positional relationship between the head and the tracks can be detected in the vicinity of the sync block from which the data is to be selectively read out, the recording method is not limited to any specific one.

Regarding the head construction on the drum, and the wrapping angle of the tape, they are not limited to those shown in this example. Alternatively, two heads may be mounted adjacently, or two or more heads may be mounted.

The example where one sample pulse is generated for one scanning is shown, but the method is not limited to this. Regarding the timing of the sample pulse, it is sufficient that the target scanning path intersects the track having the same azimuth. Thus, a plurality of samplings can be performed. In view of the polarity of the obtained sample value, the number of sample pulses can be increased as the result of the obvious extension, whereby the phase lock accuracy can be enhanced.

The countermeasure for the case where the scanning path is locked to the phase other than the target phase is not limited to the specific one which is described in the above example. It is sufficient that the scanning path can be finally moved to the target phase.

In the above example, the tracking control is performed by adjusting the tape speed with a capstan. Alternatively, another method such as a method in which the head is directly driven to perform the tracking control (DTF) can be used.

It is appreciated that the respective components can be implemented by various methods as

far as the functions equivalent to those described above can be realized. In this example, each block is constructed mainly in hardware. Alternatively, it can be implemented in software having the equivalent function. Conversely, the timing corrector can be realized by hardware logic, instead of the software. It is appreciated that any of the other components can be realized by either hardware or software.

With the above construction of the invention, the tracking error signal is sampled based on the ID information detected from the reproduced signals by the reproduced position detecting means. The tracking control is performed based on the sampled tracking error signal. Accordingly, the phase relationship between the data frame and the scanning path can be fixed without being influenced by the tracking error on the tape or the like when the reproduction is to be performed at a speed different from that in the recording. As a result, a specific region in the data frame can be selectively read out. Especially when the present invention is applied to the signal recording and reproducing apparatus in which digital compressed video signals are recorded or reproduced (e.g., a digital VTR), the high-speed reproduced image quality can be remarkably improved.

Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

## Claims

1. An apparatus for recording and reproducing data comprising:
  - recording medium traveling means for making a recording medium to travel in a first direction;
  - rotating drum means which rotates with an angle with respect to the first direction, the rotating drum means having a head used for recording and reproducing the data;
  - recording means for recording first data of the data onto a first portion of the recording medium, the first portion being commonly passed by the head at three or more predetermined speeds; and
  - reproducing means for reproducing the first data which is recorded at least on the first portion of the recording medium at each of the three or more predetermined speeds.
2. An apparatus according to claim 1, wherein the first portion is part of tracks which are formed



on the recording medium, and the tracks including the first portions are located on the recording medium at a predetermined first pitch along the first direction.

3. An apparatus according to claim 1, wherein the first portion is located in the vicinity of the center of a track formed on the recording medium.
4. An apparatus according to claim 1, wherein the data is video data, and the first data is at least part of video data of one frame corresponding to a screen selected at a predetermined rate among a plurality of screens, or at least part of video data of one field corresponding to the selected screen.
5. An apparatus according to claim 1, wherein the data is video data, and the first data includes a component which coarsely constitutes an image.
6. An apparatus according to claim 1, wherein the data is video data, and the first data includes video data to which at least an orthogonal base transform and quantization are performed.
7. An apparatus according to claim 6, wherein the orthogonal base transform is a discrete cosine transform or an Hadamard transform.
8. An apparatus according to claim 6, wherein the first data includes at least an upper bit of a DC component obtained by the orthogonal base transform.
9. An apparatus according to claim 1, wherein the data is video data,  
the recording means includes at least one of:  
first redundant component suppressing means for suppressing a visual redundant component or a statistic redundant component of the video data, only by using video data of one frame or video data of one field; and  
second redundant component suppressing means for suppressing a visual redundant component or a statistic redundant component of the video data, only by using video data of plural frames or video data of plural fields, and  
the reproducing means includes at least one of:  
first recovering means for recovering the suppressed video data by the first redundant component suppressing means to the original video data; and  
second recovering means for recovering

the suppressed video data by the second redundant component suppressing means to the original video data.

10. An apparatus according to claim 1, wherein the data is video data having a suppressed visual redundant component or a suppressed statistic redundant component, and the first data includes at least part of the suppressed video data of one frame or at least part of the suppressed video data of one field.
11. An apparatus according to claim 1, wherein the first data of the data and the remaining data of the data are input into the recording means separately from each other.
12. An apparatus according to claim 1, wherein the recording means includes means for adding a contents identification code for identifying the contents of the data to at least one of the first data of the data and the remaining data of the data, and the reproducing means includes means for identifying the contents of the data based on the contents identification code.
13. An apparatus according to claim 1, wherein the first data includes a track identification code for identifying a type of track formed on the recording medium.
14. An apparatus according to claim 1, wherein the recording means includes at least one of:  
means for adding, to the first data of the data, a first position identification code indicating the position of the first data on a track;  
means for adding, to second data which is recorded on the track on which the first data is recorded in a forward portion thereof with respect to the first data, a second position identification code indicating the position of the second data on the track; and  
means for adding, to third data which is recorded on the track on which the first data is recorded in a backward portion thereof with respect to the first data, a third position identification code indicating the position of the third data on the track.
15. An apparatus according to claim 14, wherein the reproducing means includes:  
detection means for detecting a relative positional relationship between the head and the first portion, based on at least one of the first, second, and third position identification codes recorded on the track; and  
adjusting means for adjusting the relative positional relationship between the head and



the first portion so that the head passes the first portion, on the basis of the detected relative positional relationship.

16. An apparatus according to claim 15, wherein the adjusting means adjusts the relative positional relationship between the head and the first portion, by variably setting at least one of a traveling speed of the recording medium, a rotation speed of the rotating drum means and a position of the head mounted on the rotating drum means.

17. An apparatus for recording and reproducing data comprising:

recording medium traveling means for making a recording medium to travel in a first direction;

rotating drum means which rotates with an angle with respect to the first direction, the rotating drum means having a head used for recording and reproducing the data;

recording means for recording first data of the data onto a first portion of the recording medium, the first portion being commonly passed by the head at three or more predetermined speeds and for recording second data of the data which is different from the first data onto a second portion of the recording medium, the second portion being passed by the head at at least one of the three or more predetermined speeds; and

reproducing means for reproducing the first data which is recorded at least on the first portion of the recording medium at each of the three or more predetermined speeds.

18. An apparatus according to claim 17, wherein the first portion is part of tracks which are formed on the recording medium, and the tracks including the first portions are located on the recording medium at a predetermined first pitch along the first direction, and wherein the second portion is part of tracks which are formed between the tracks each including the first portion, and the tracks each including the second portion and the tracks each including the first portion are located on the recording medium at a predetermined second pitch along the first direction.

19. An apparatus according to claim 17, wherein the second portion is part of tracks each including the first portion, the second portion being positioned differently from the first portion.

20. An apparatus according to claim 17, wherein the first and second portions are located in the vicinity of the center of a track formed on the recording medium.

21. An apparatus according to claim 17, wherein the data is video data, the first data includes a component which coarsely constitutes an image, and the second data includes a component which constitutes the image as coarsely as that in the first data or a component which constitutes the image at a higher definition degree than that in the first data.

22. An apparatus according to claim 17, wherein the data is video data, and the first data and the second data include video data to which at least an orthogonal base transform and quantization are performed.

23. An apparatus according to claim 22, wherein the orthogonal base transform is a discrete cosine transform or an Hadamard transform.

24. An apparatus according to claim 22, wherein the first data includes at least upper bits of a direct current component which is obtained by the orthogonal base transform, and the second data includes at least a component which is equivalent to that in the first data or upper bits of an alternate current component which is closest to the direct current next to the direct current component in the first data.

25. An apparatus for recording and reproducing video data comprising:

recording medium traveling means for making a recording medium to travel in a first direction;

rotating drum means which rotates with an angle with respect to the first direction, the rotating drum means having a head used for recording and reproducing the data;

means for dividing video data constituting one screen into a plurality of blocks;

means for performing a variable length coding for each of the plurality of blocks, to suppress the statistic redundancy of the video data;

means for assigning a first priority based on a position of a block on the screen and a second priority based on the importance of components included in the block to data having fixed length or variable length in the variable-length coded block; means for determining, from the data having

fixed length or variable length in the variable-length coded block, first data which is to

be reproduced at three or more predetermined speeds, based on the first priority and the second priority;

means for rearranging the data having fixed length or variable length in the variable-length coded block in order for the determined first data to be recorded onto a first portion of the recording medium, the first portion being commonly passed by the head at the three or more predetermined speeds;

recording means for recording the rearranged data onto the recording medium; and

reproducing means for reproducing the first data which is recorded at least on the first portion of the recording medium at each of the three or more predetermined speeds.

26. An apparatus according to claim 25, wherein the first priority is higher as the position of the block is closer to the center of the screen.

27. An apparatus according to claim 25, wherein the second priority is higher as components among the components included in the block constitute an image more coarsely.

28. An apparatus according to claim 25, wherein the first data is determined based on a first rule by which the first priority is used from the highest one to the lowest one, a second rule by which the second priority is used from the highest one to the lowest one, and a third rule by which the second priority is used in preference to the first priority.

29. An apparatus according to claim 25, wherein the recording means includes subsampling means for performing subsampling by each block at least for direct current components of the data having fixed length or variable length in the variable-length coded block, and for classifying at least the direct current components into a first group and a second group, and wherein the data having fixed length or variable length in the variable-length coded block is rearranged depending on whether the data having fixed length or variable length in the variable-length coded block belongs to the first group or to the second group.

30. An apparatus according to claim 29, wherein the subsampling means extracts alternate blocks in the horizontal direction and in the vertical direction of the screen, whereby at least the direct current components are classified into the first group and the second group.

31. An apparatus according to claim 29, wherein the subsampling means performs the subsampling by each block only for the direct current components of the data having fixed length or variable length in the variable-length coded block.

32. An apparatus according to claim 25 or 29, wherein at least direct current components of the data are recorded as data having fixed length.

33. An apparatus according to claim 29, wherein the reproducing means includes interpolation means for, when at least part of data included in one of the first and the second groups is lost in the reproduction, interpolating at least a direct current component of the lost data by using data included in the other group.

34. An apparatus according to claim 33, wherein the interpolation means interpolates at least a direct current component of the lost data by selectively using the data of image blocks which is positioned in the vicinity of an image block corresponding to the lost data among the data included in the other group.

35. An apparatus according to claim 33, wherein the interpolation means interpolates at least a direct current component of the lost data by selectively using data of pixels in a peripheral portion of an image block corresponding to the lost data and data of pixels externally adjacent to the image block among the data included in the other group.

36. An apparatus for recording and reproducing data comprising:

recording medium traveling means for making a recording medium to travel in a first direction;

rotating drum means having a head used for recording and reproducing the data, the head traversing the recording medium obliquely to the first direction, whereby tracks which are oblique to the first direction are formed on the recording medium;

recording means for recording data in a predetermined portion of the recording medium, the predetermined portion being passed by the head at a first speed of the recording medium; and

reproducing means for reproducing the data recorded in the predetermined portion of the recording medium,

wherein the data is divided into a plurality of sync blocks, and the plurality of sync blocks

are recorded on each of the tracks and pilot signals are recorded periodically in several successive tracks, and

the reproducing means includes:

reproduced position detecting means for detecting the predetermined portion of the recording medium in the reproduction at a second speed, being not equal to the first speed, and for generating a timing signal indicating a position of a reproduced signal corresponding to the predetermined portion;

tracking error detecting means for detecting a relative positional deviation of the track with respect to the head from the pilot signal included in the reproduced signal, and for generating a tracking error signal depending on the detected relative positional deviation;

sampling means for sampling the tracking error signal in accordance with the timing signal; and

adjusting means for adjusting the position of the track relative to the head path, so that the tracking error signal is substantially set to be 0.

37. An apparatus according to claim 36, wherein each of the plurality of sync blocks includes ID information for identifying the sync block, and the reproduced position detecting means generates the timing signal when the ID information matches predetermined ID information to be detected.
38. An apparatus according to claim 36, wherein each of the plurality of sync blocks includes ID information for identifying the sync block, and the reproduced position detecting means generates the timing signal at a timing based on the rotation of the rotating drum means and the ID information.
39. An apparatus according to claim 36, further comprising:  
correcting means for, when the timing signal is not obtained from the reproduced position detecting means, shifting the position of the track relative to the head path by a predetermined amount until the pulse signal is obtained.
40. An apparatus according to claim 36, wherein the data is a video signal which is digitized and compressed, and the video signal includes a plurality of video frames.

Fig. 1

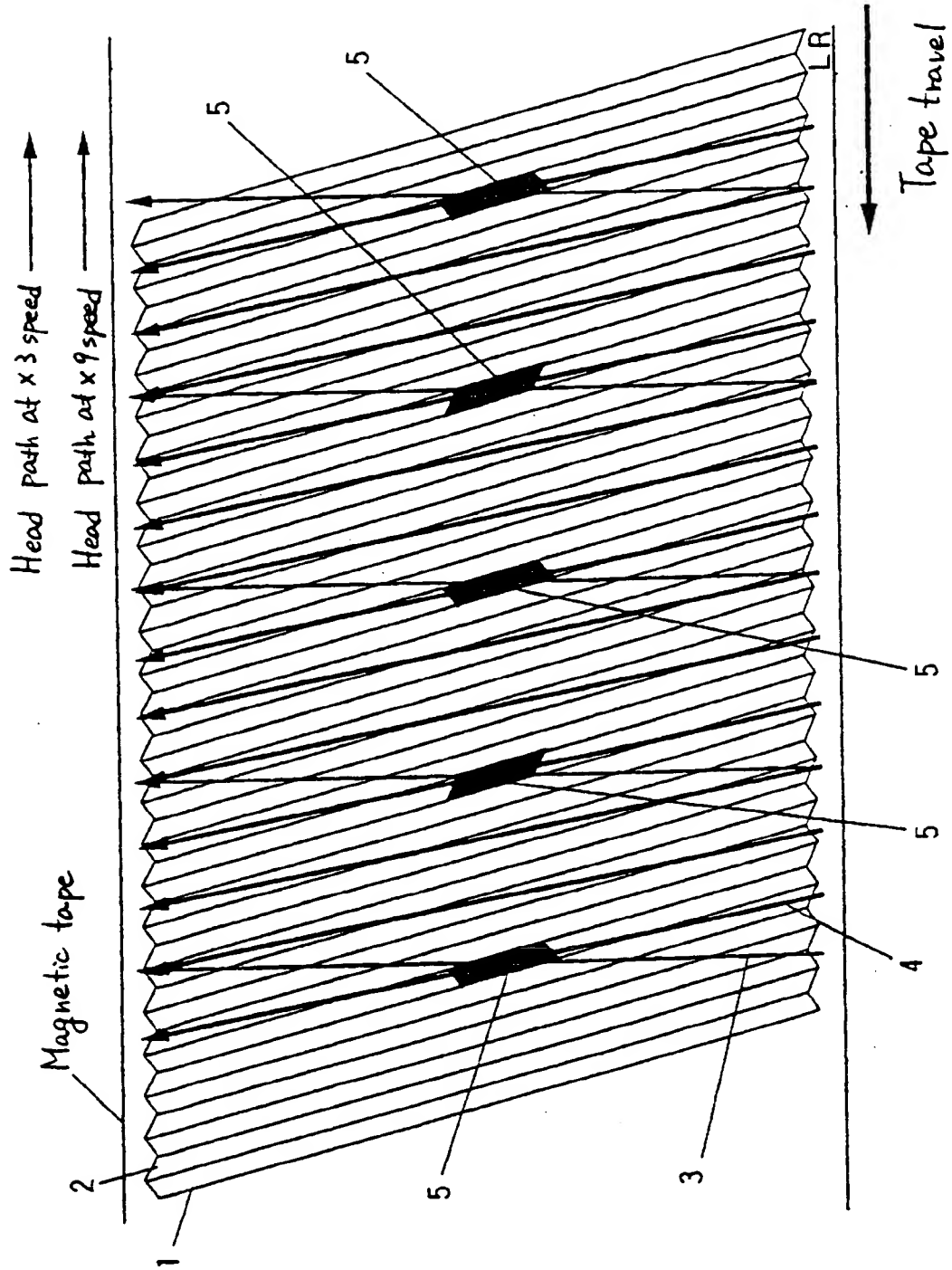


Fig. 2

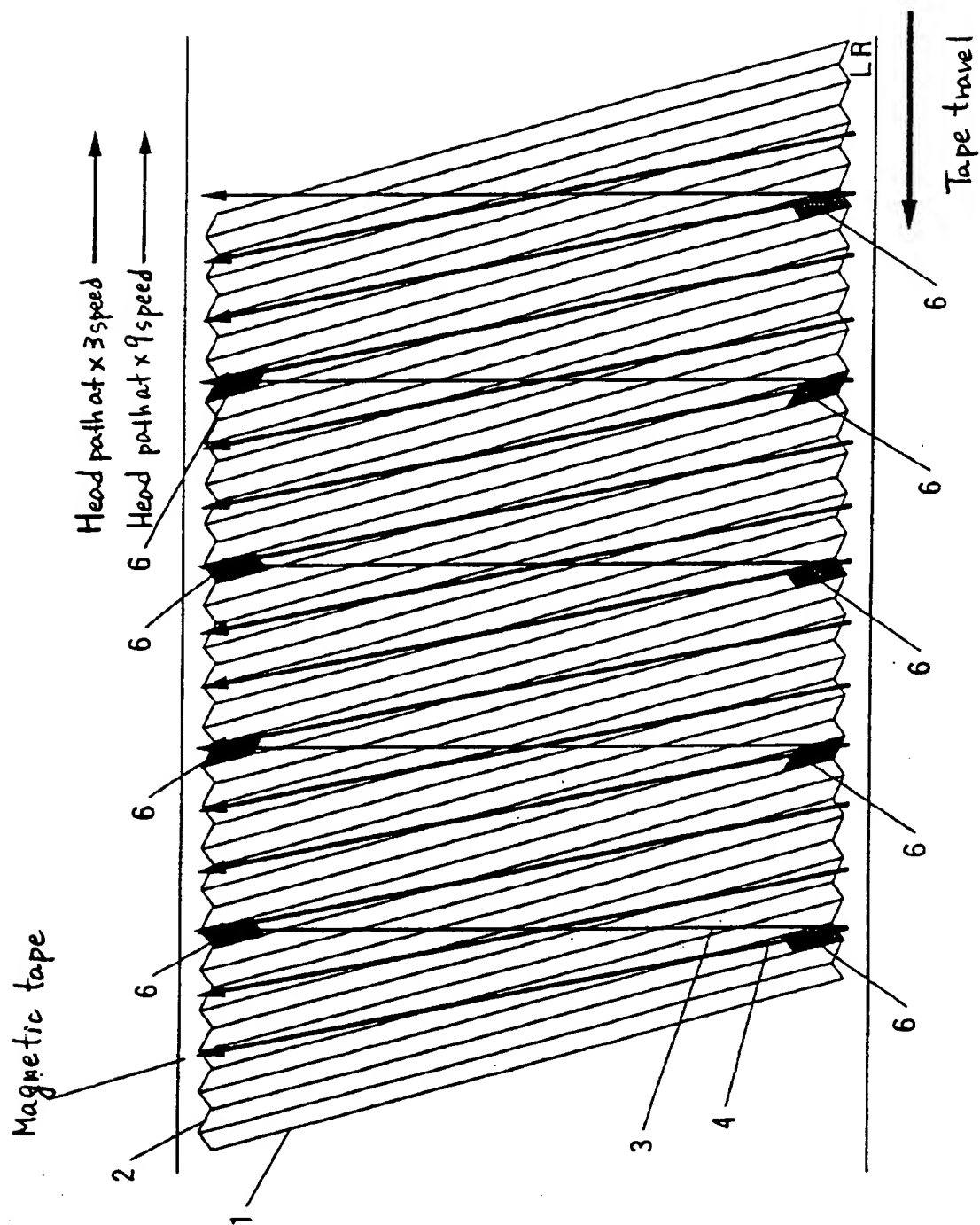


Fig. 3

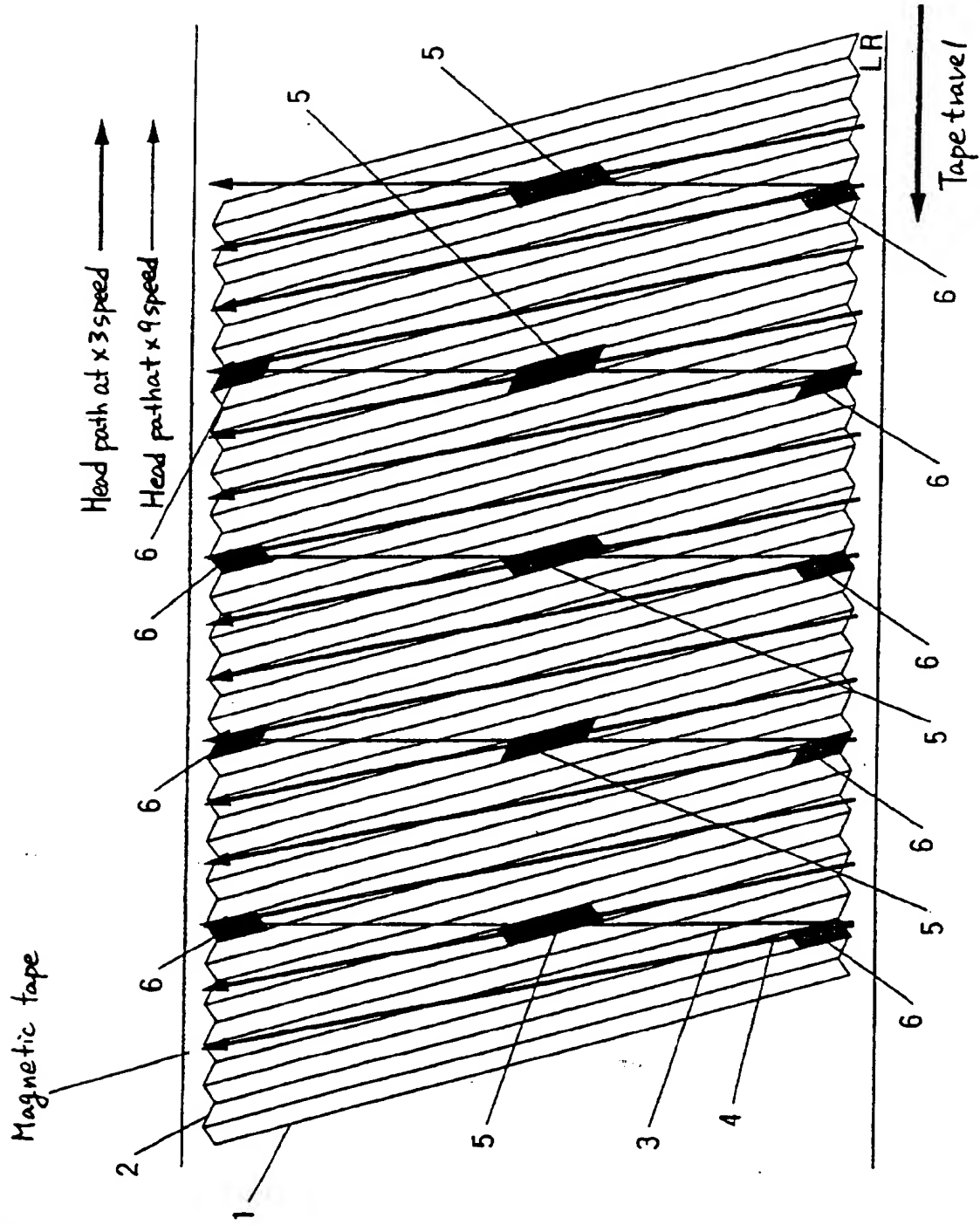


Fig. 4

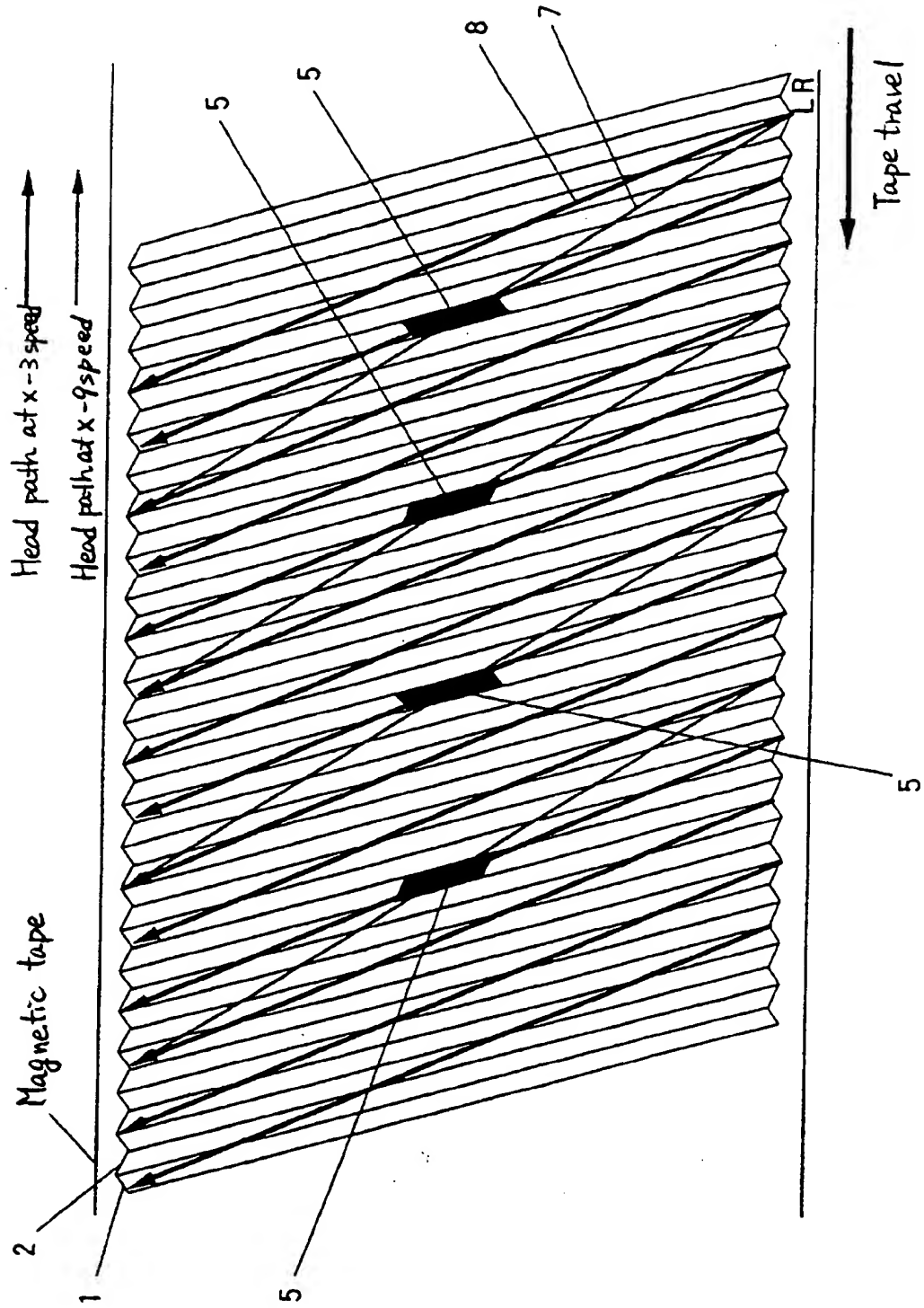


Fig. 5

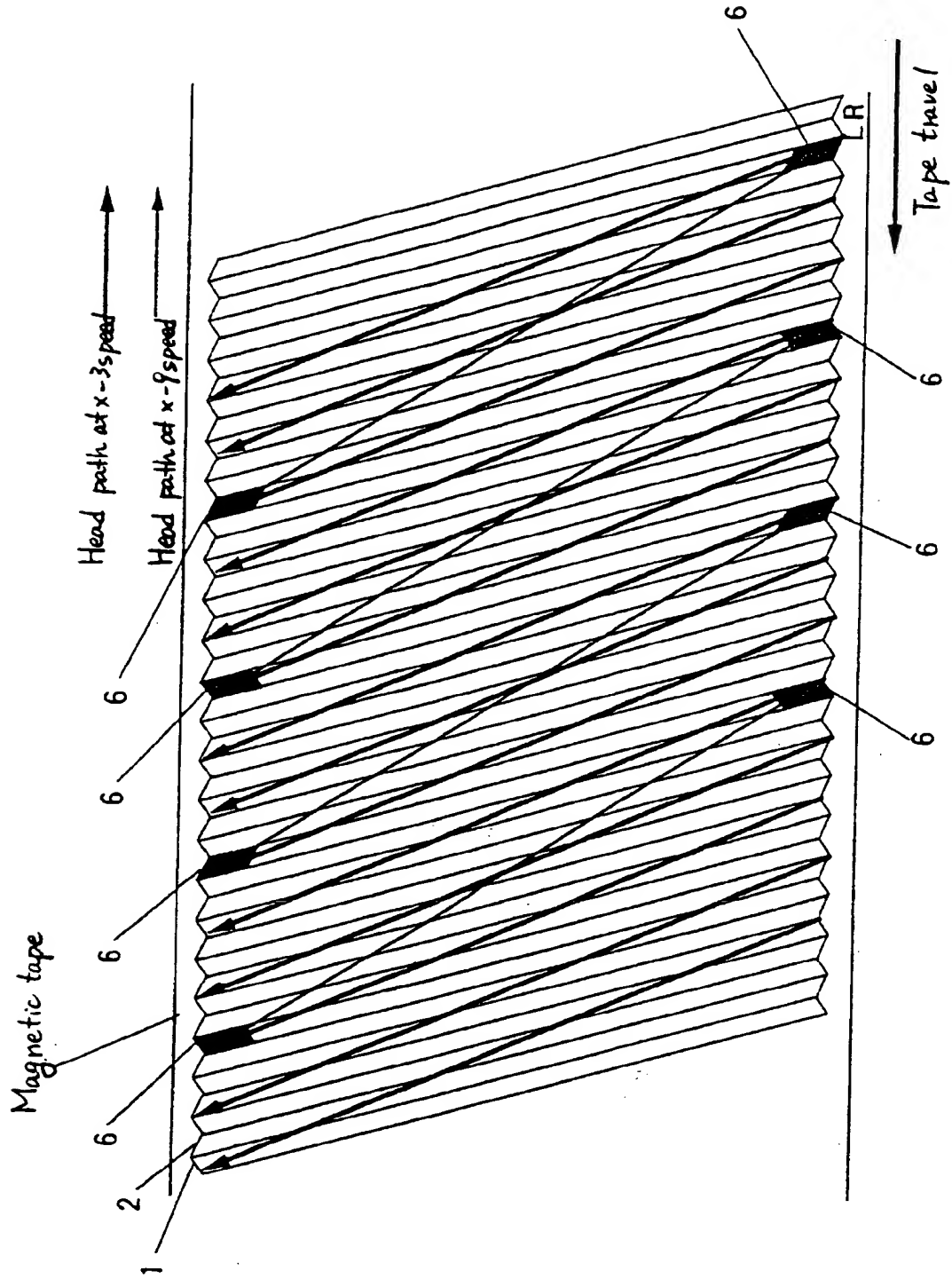




Fig. 6

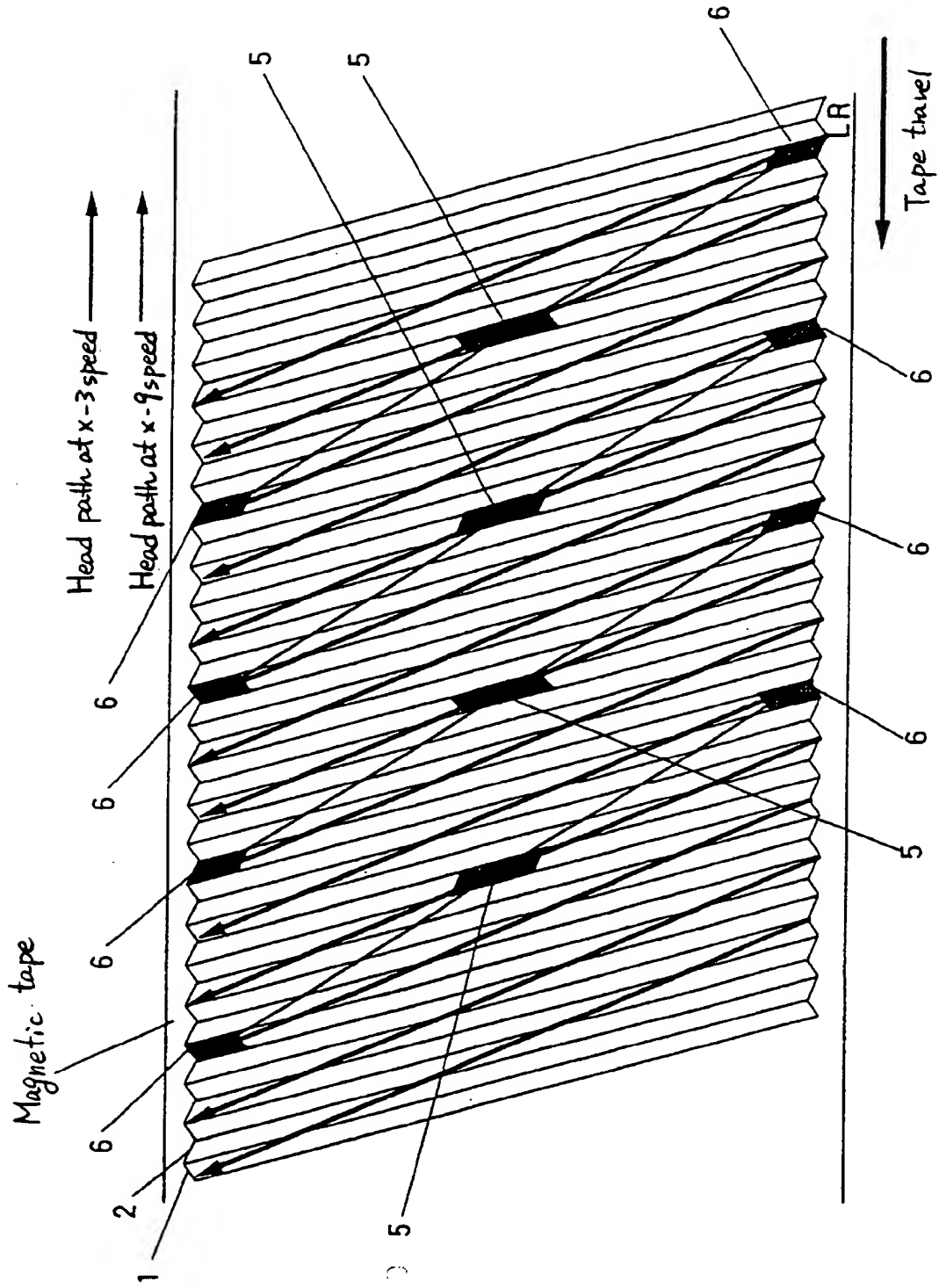


Fig. 7

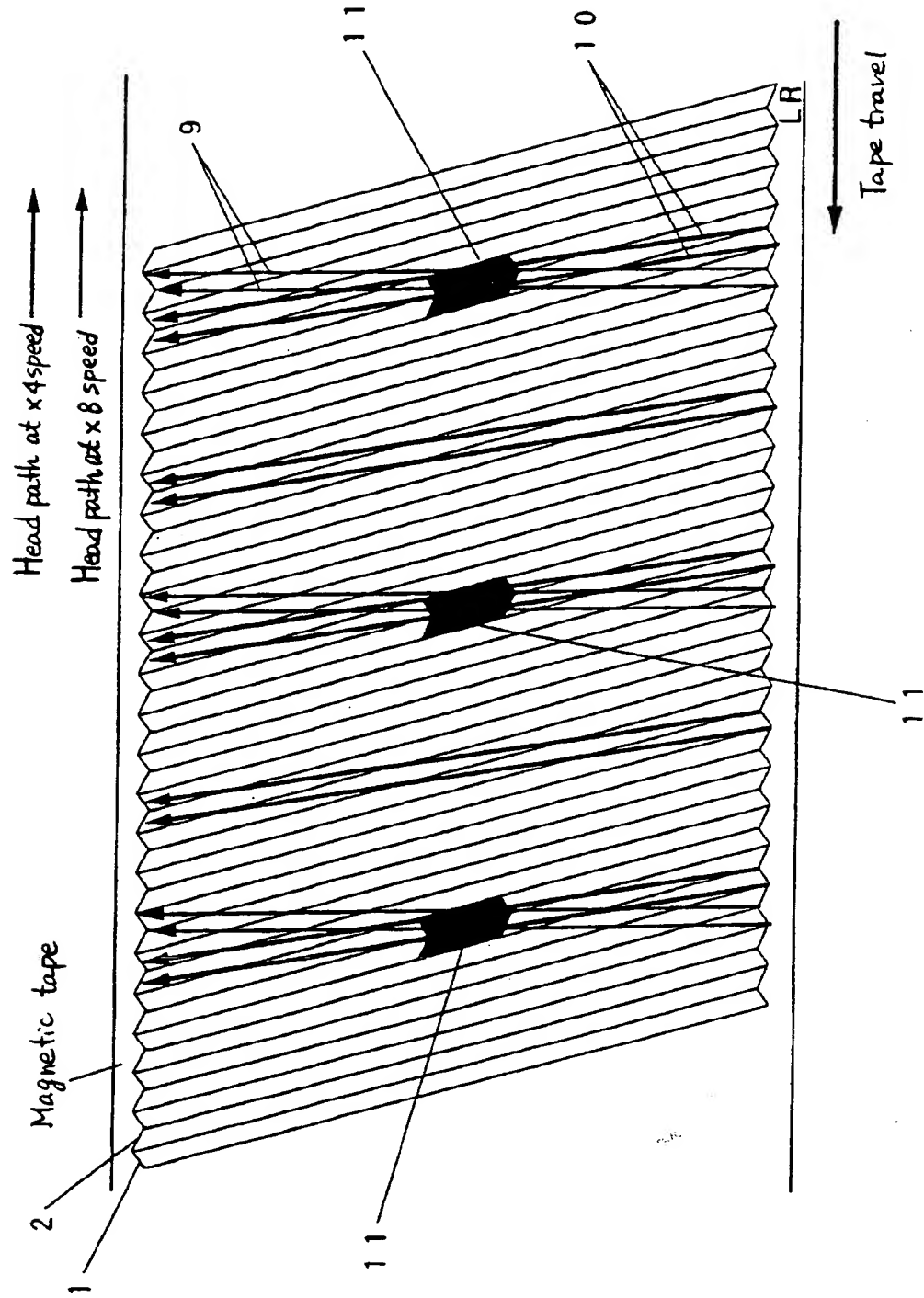


Fig. 8

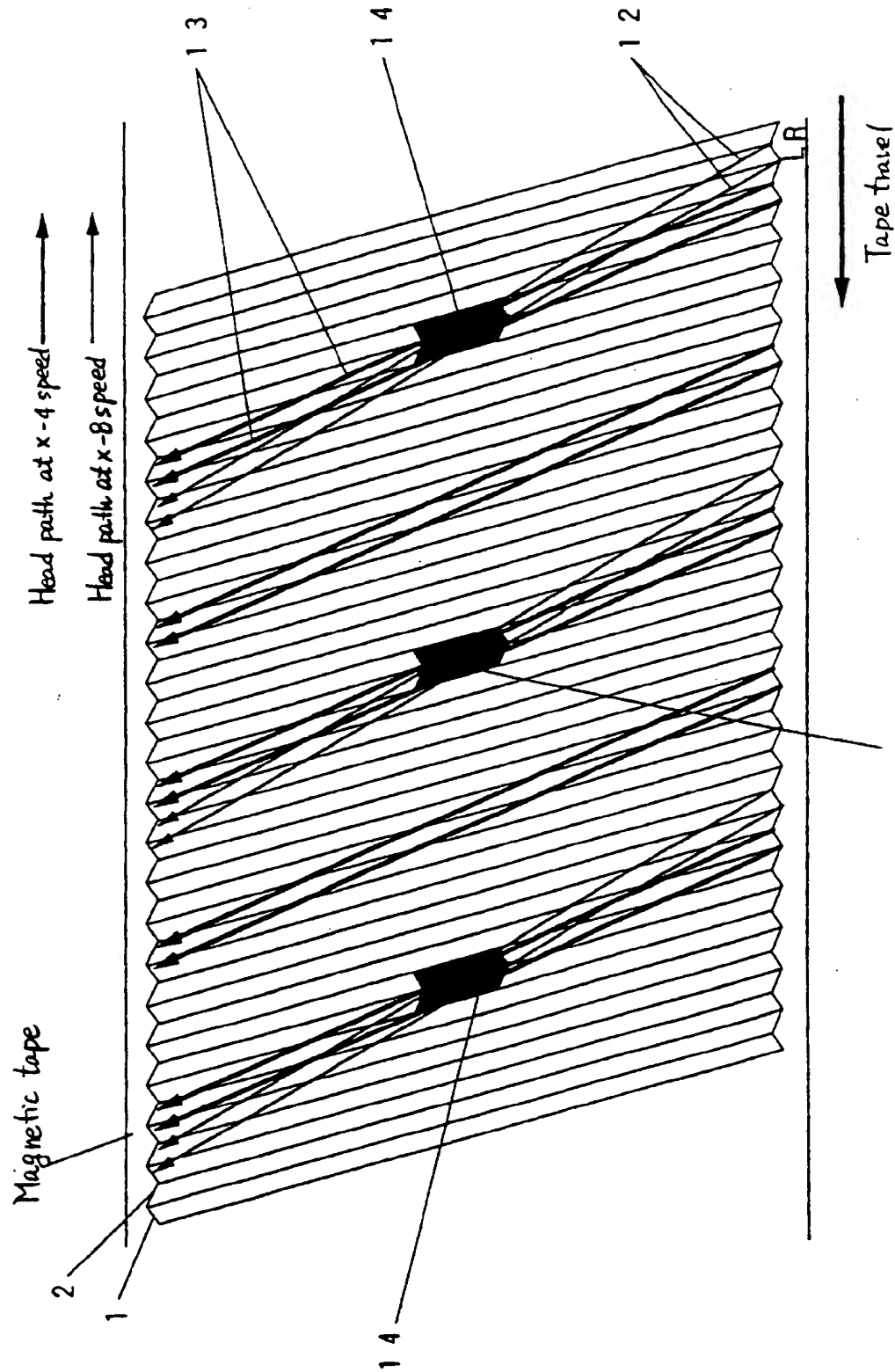


Fig. 9

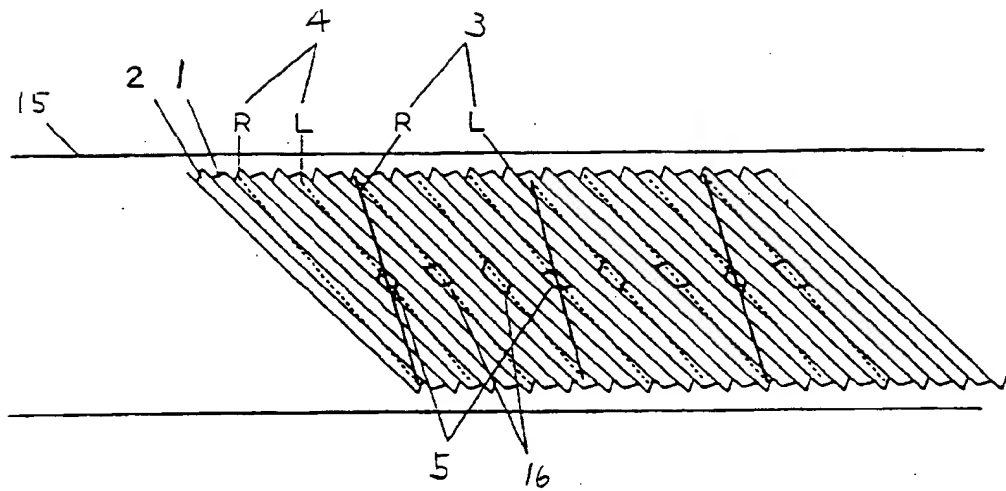


Fig. 10

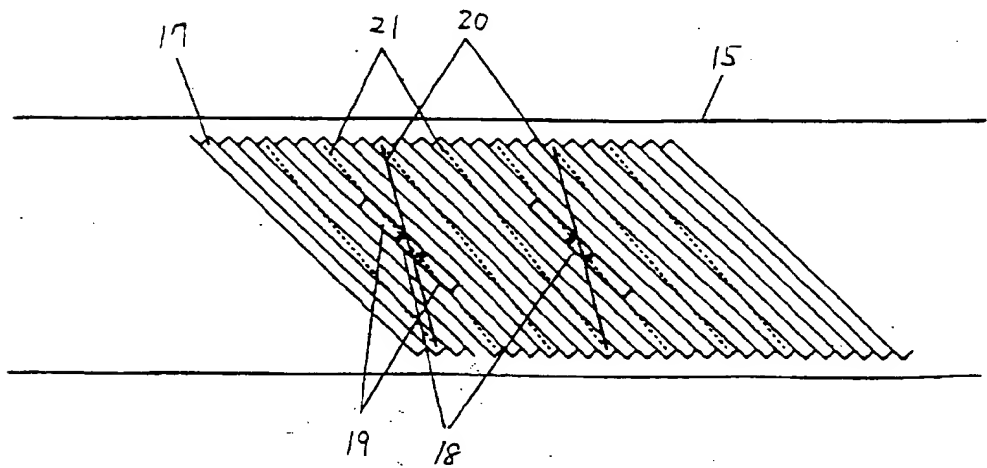


Fig. 11

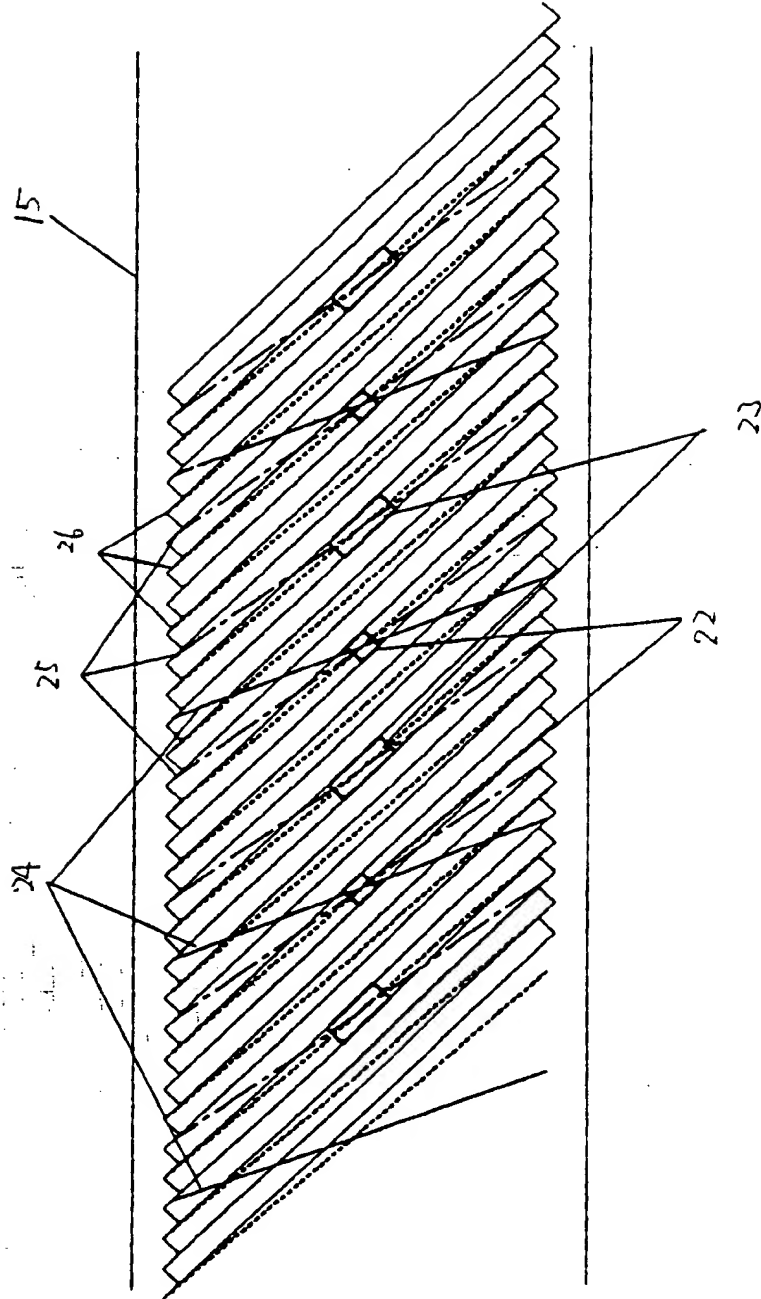


Fig.12

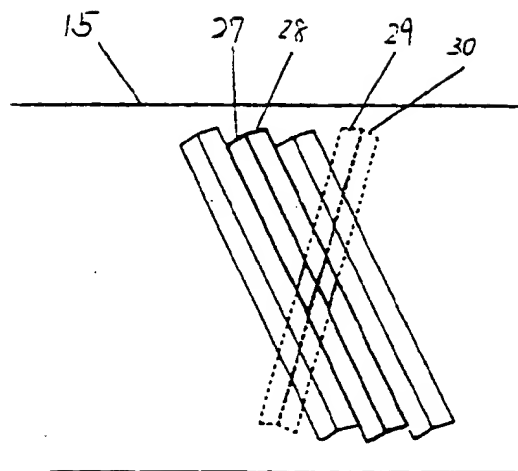


Fig. 13

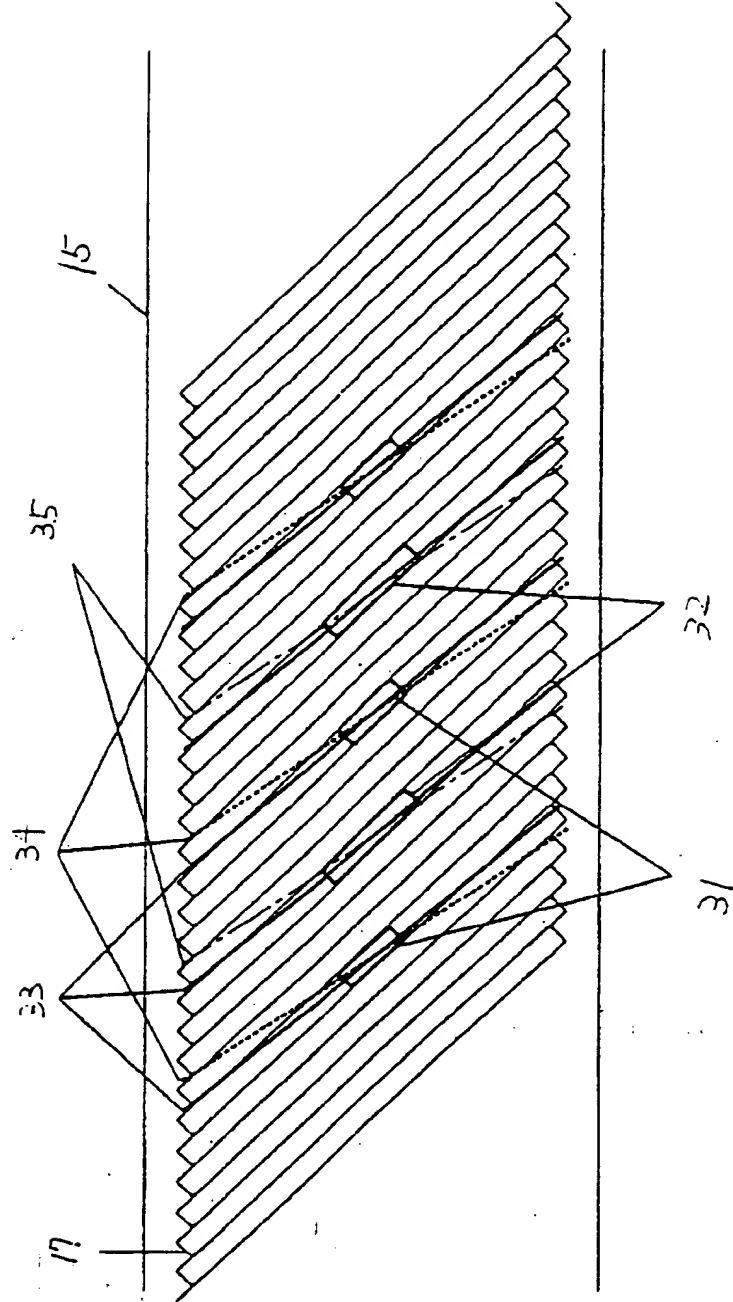
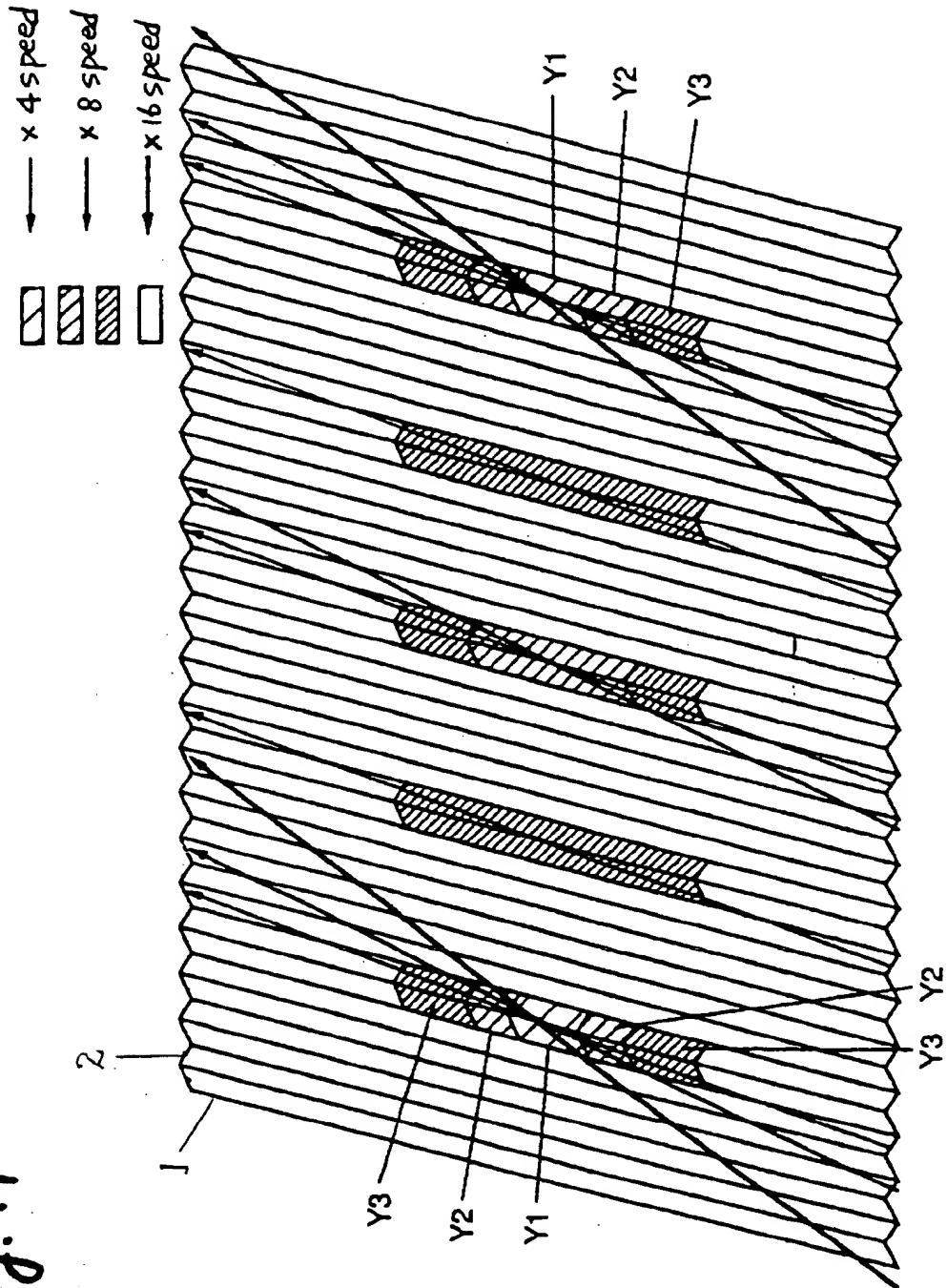




Fig. 14



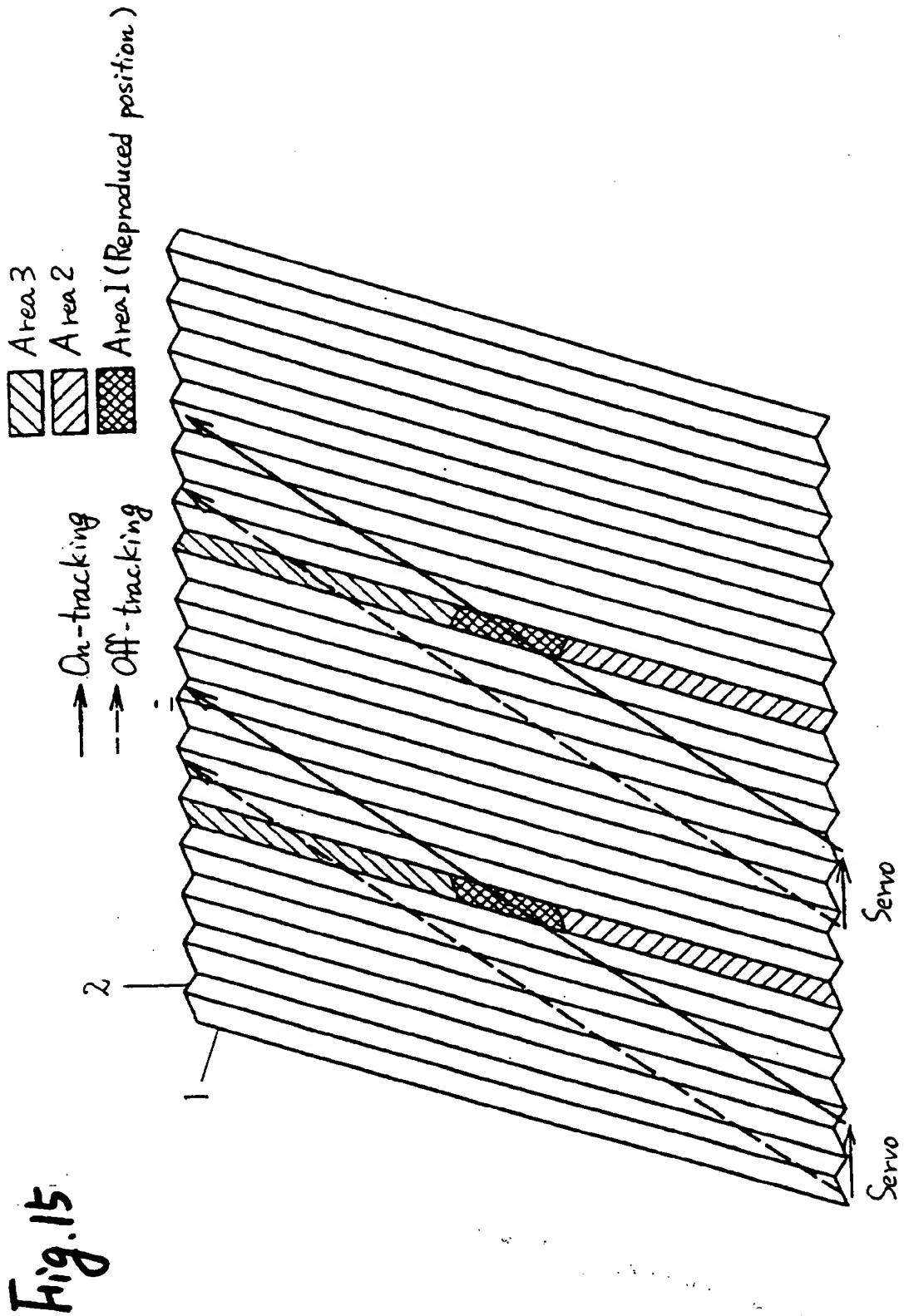


Fig. 16

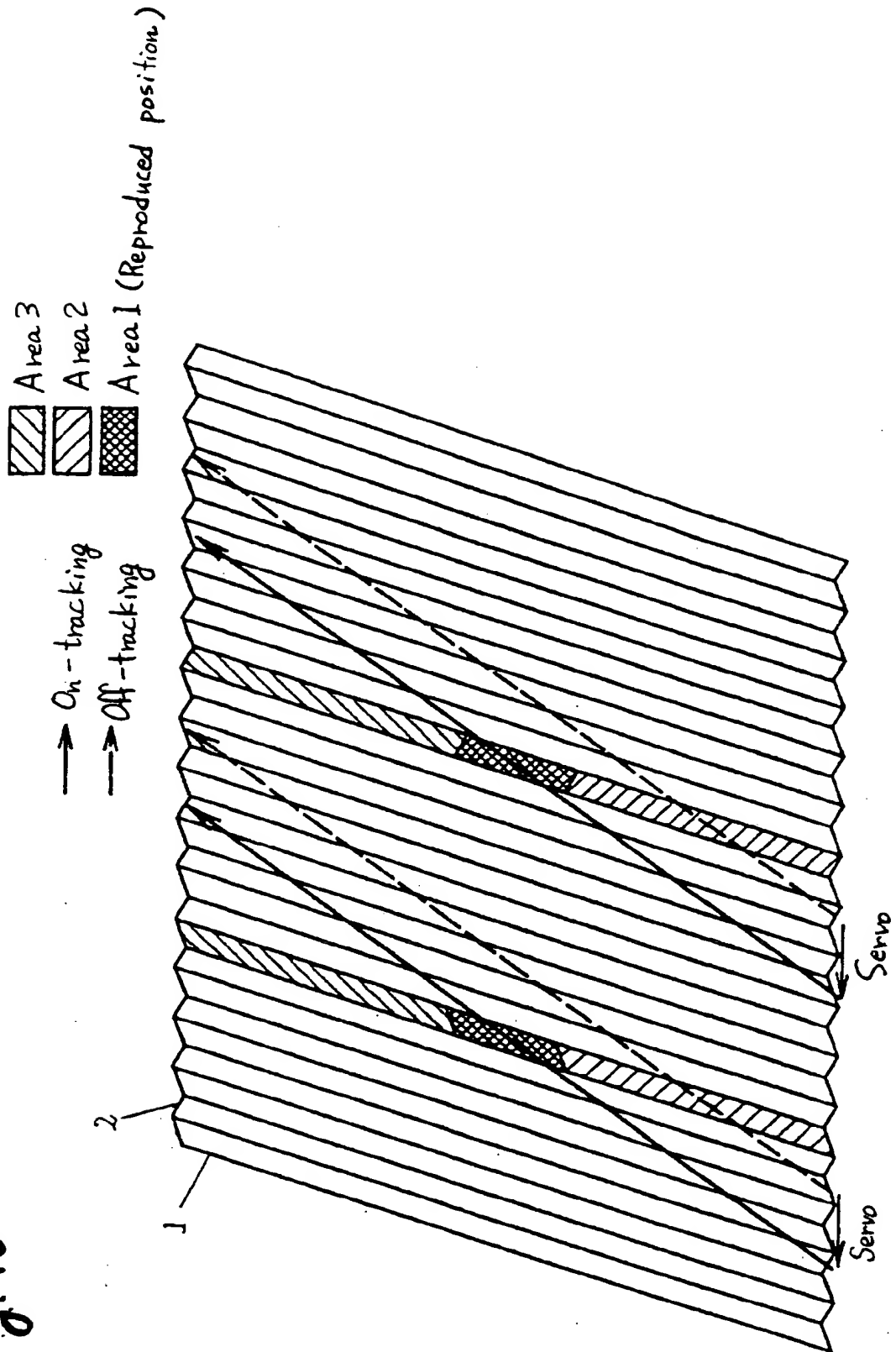


Fig. 17

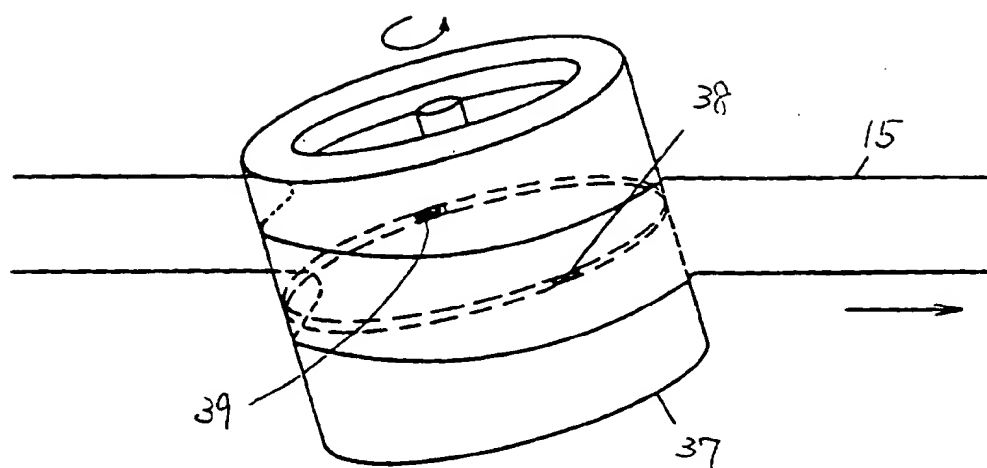


Fig. 18

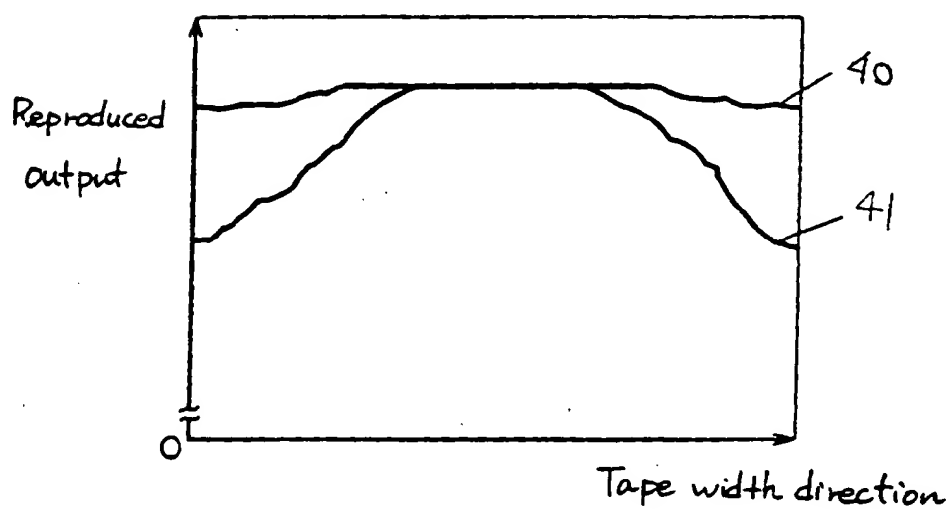


Fig. 19

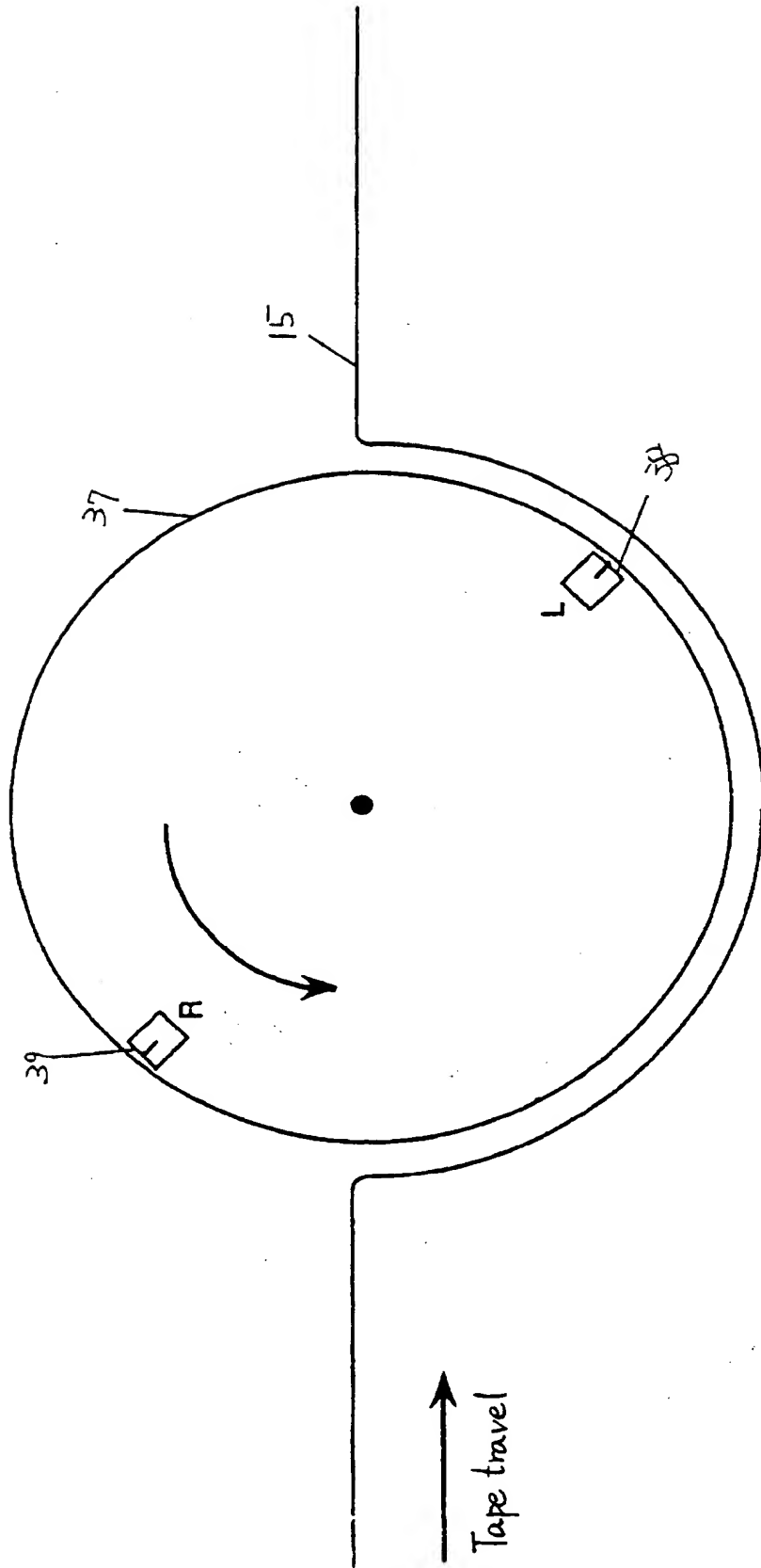


Fig. 20

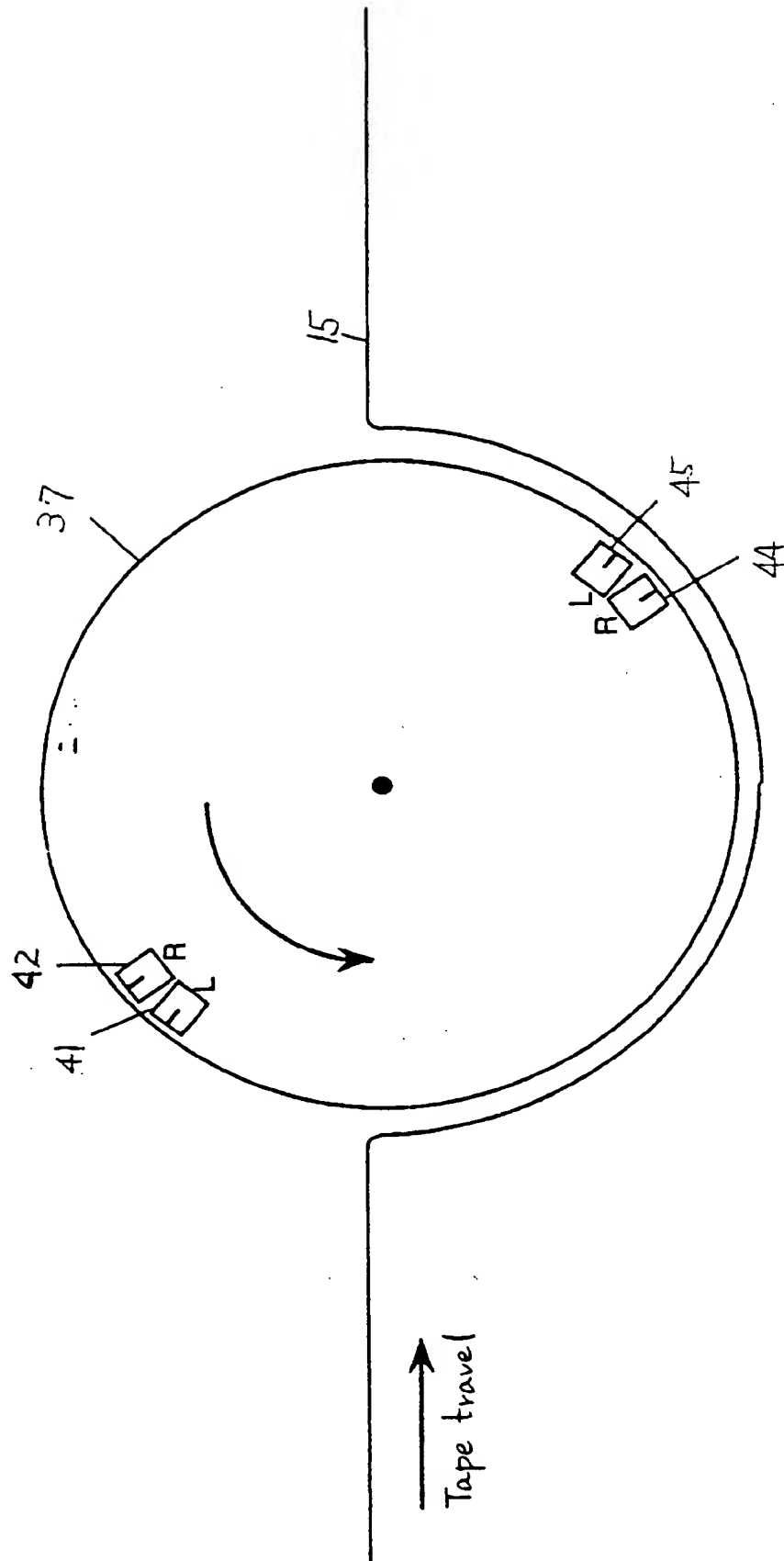


Fig. 21A

		Horizontal high-frequency component							
Vertical high-frequency component	DC	A12	A13	.	.	.	.	.	A18
	A21	A22							.
	A31								.
	.								.
	.								.
	.					.			.
	.								.
	A81	.	.	.	.	.	.	.	A88

Fig. 21B

		Horizontal high-frequency component							
Vertical high-frequency component	8	16	19	22	26	27	29	34	34
	16	16	22	26	27	29	34	37	37
	19	22	26	27	29	34	37	38	38
	22	26	27	29	34	37	38	40	40
	26	27	29	34	37	38	40	48	48
	27	29	34	37	38	40	48	58	58
	29	34	37	38	40	48	58	69	69
	34	37	38	40	48	58	69	83	83

Fig. 22

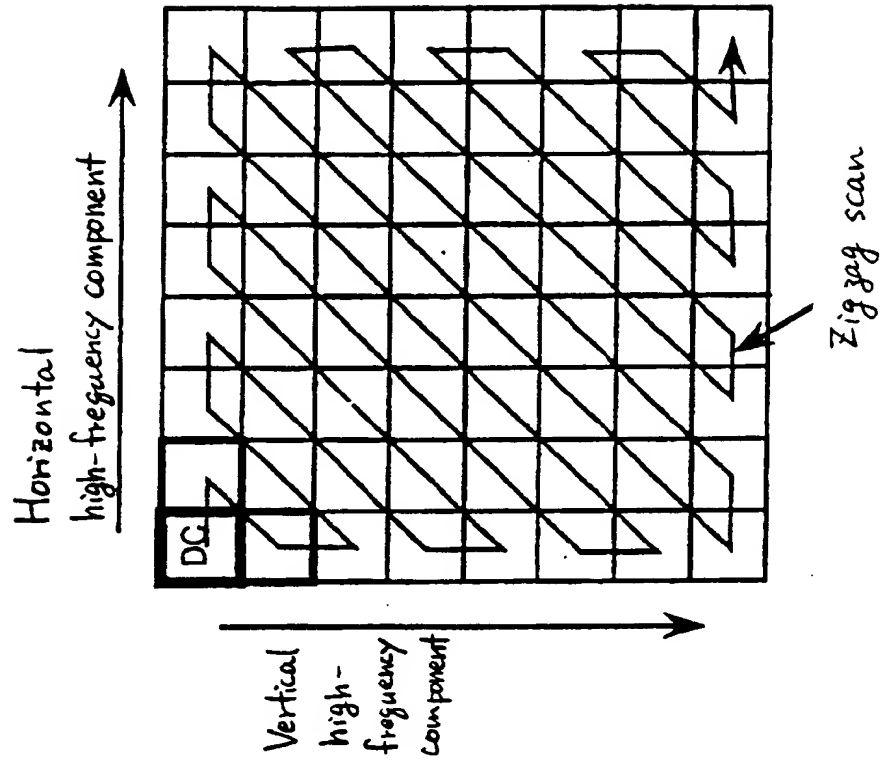




Fig. 23

DC: Fixed length  
AC: VLC

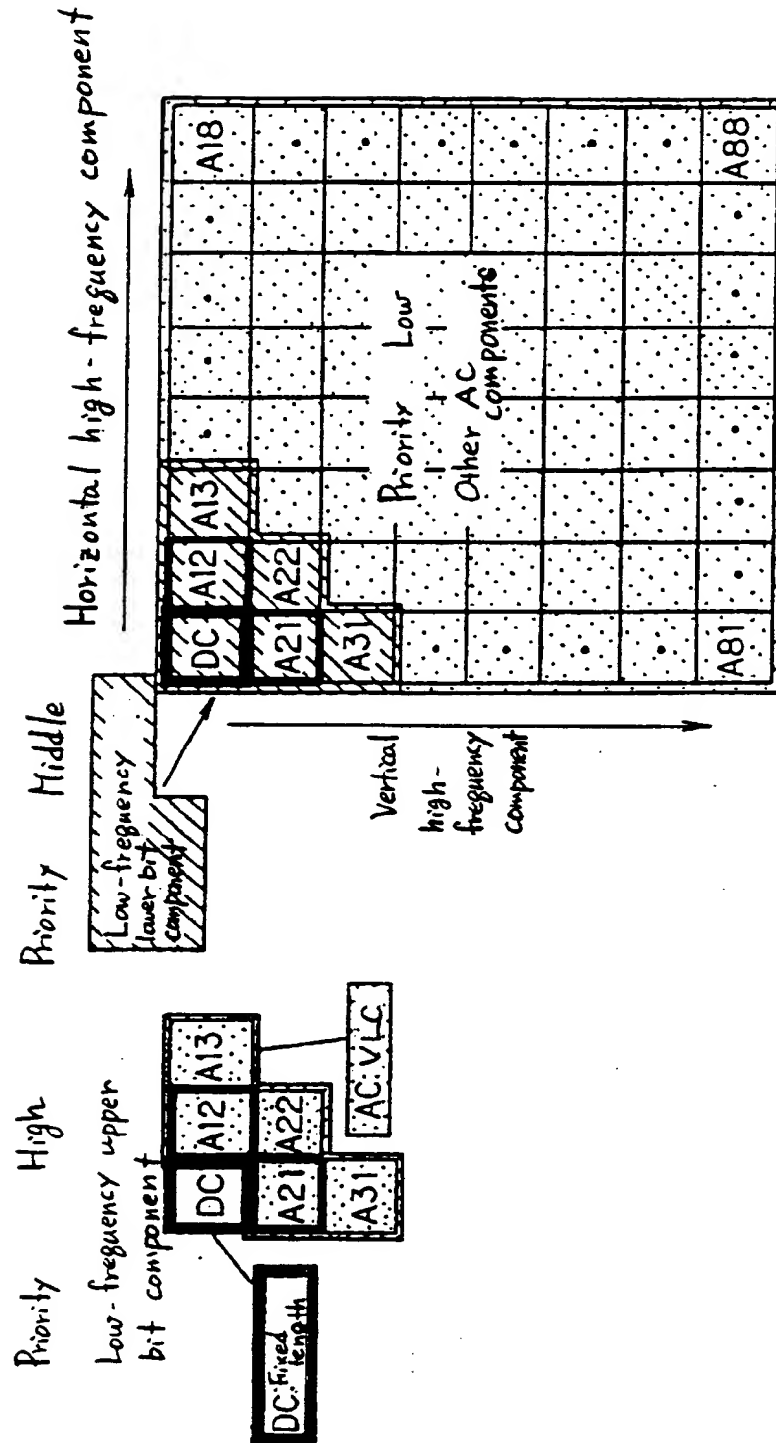
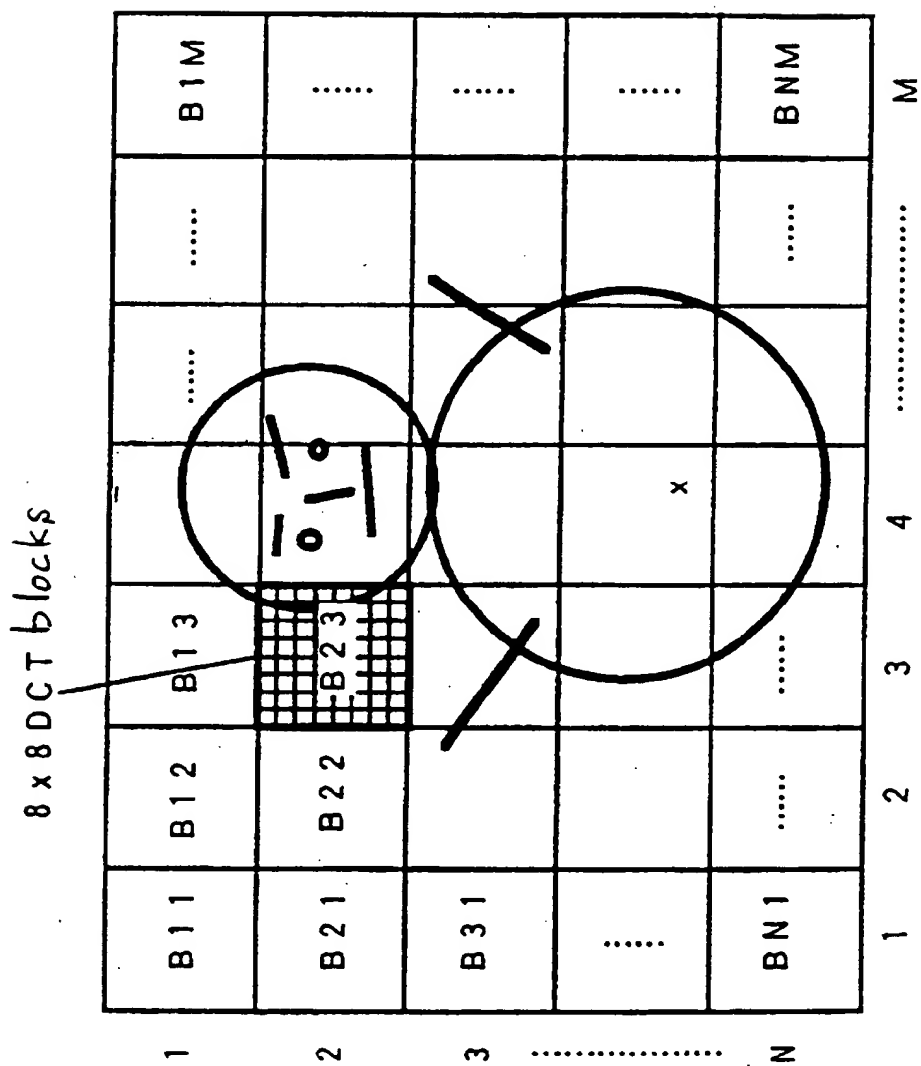


Fig. 24



# Priority of DCT blocks

Fig. 25A

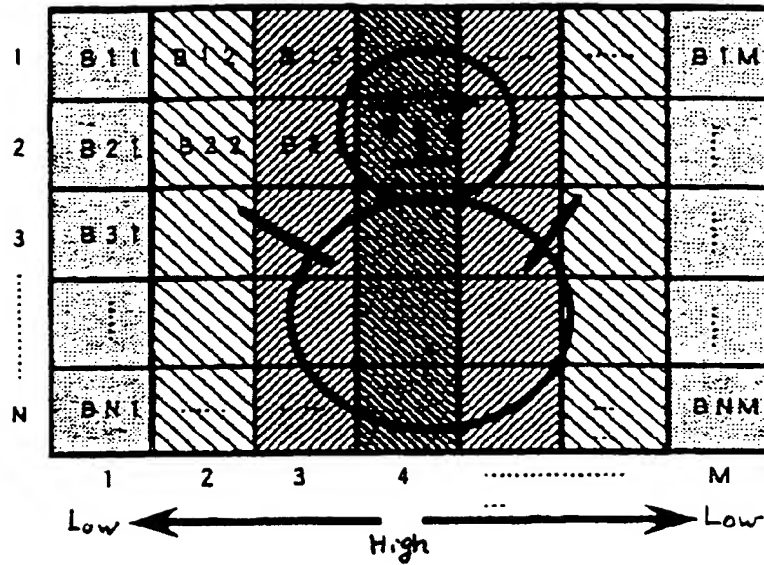


Fig. 25B

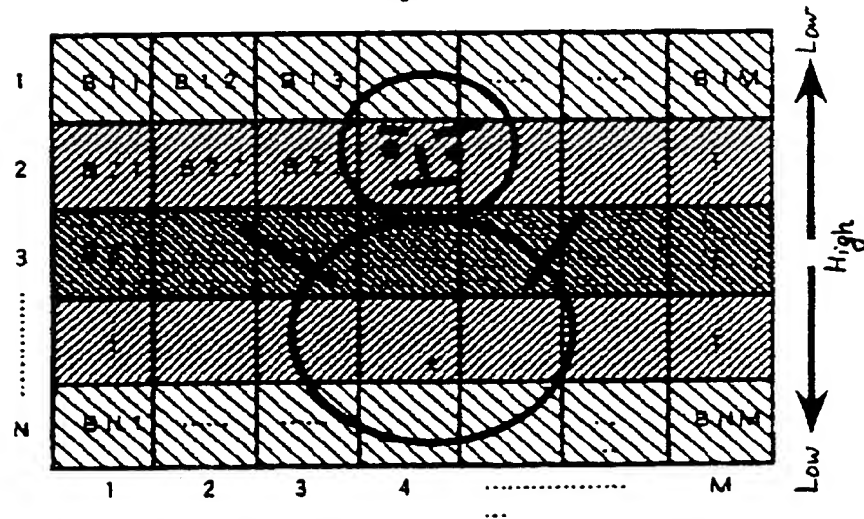


Fig. 25C

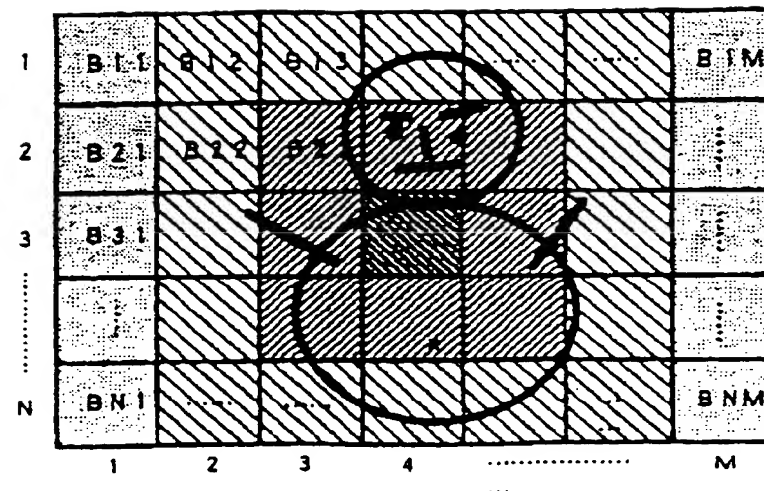


Fig. 26

Priority

Components in block					
	DC upper bits (Fixed length)	AC upper bits (Zigzag scan + VLC)	DC lower bits (Fixed length)	AC lower bits (Zigzag scan + VLC)	Remaining AC components (Zigzag scan + VLC)
DCT	1	4	7	10	13
block	2	5	8	11	14
position	3	6	9	12	15
	Screen center				
	Middle				
	Screen edge				

Fig. 27

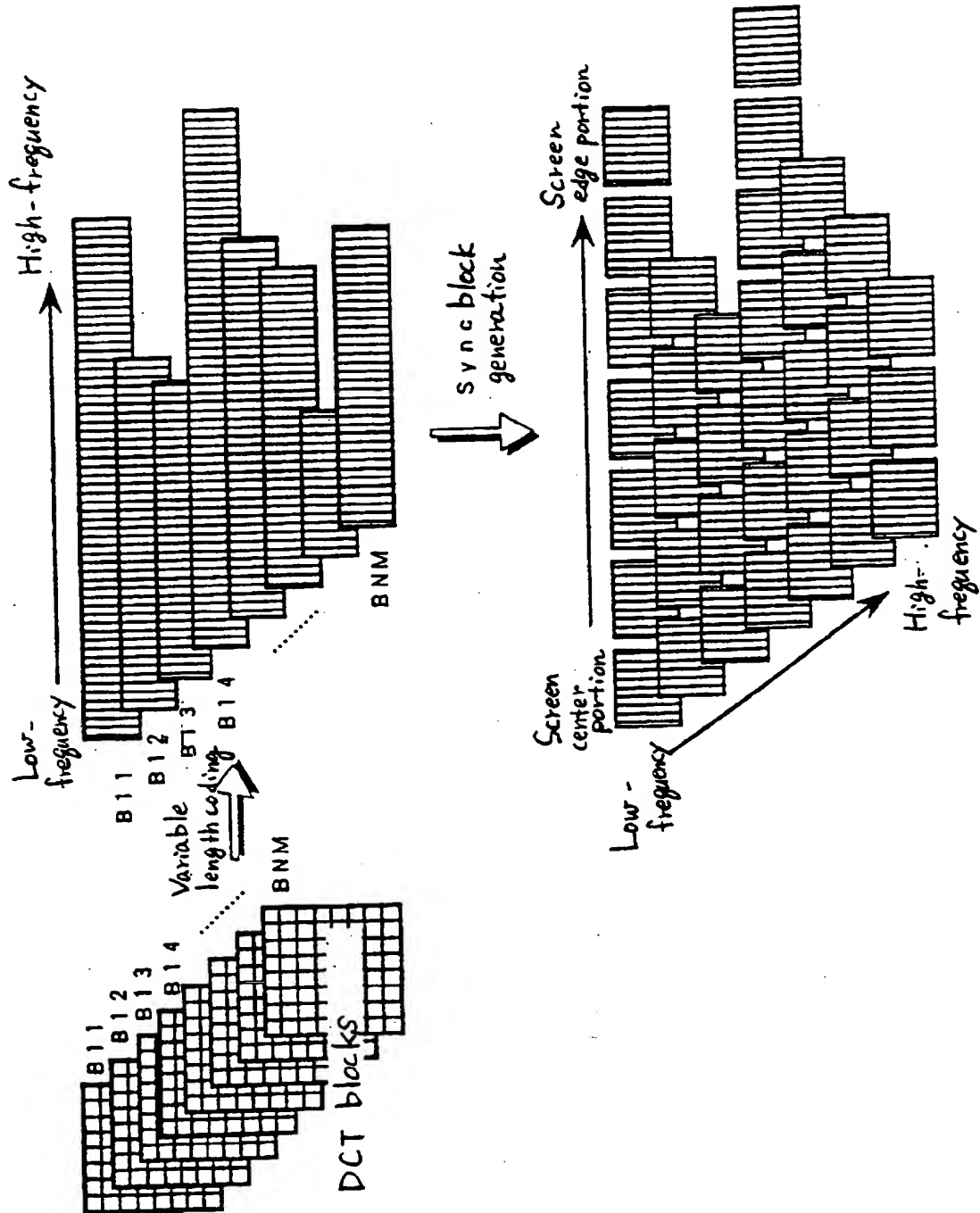


Fig. 28

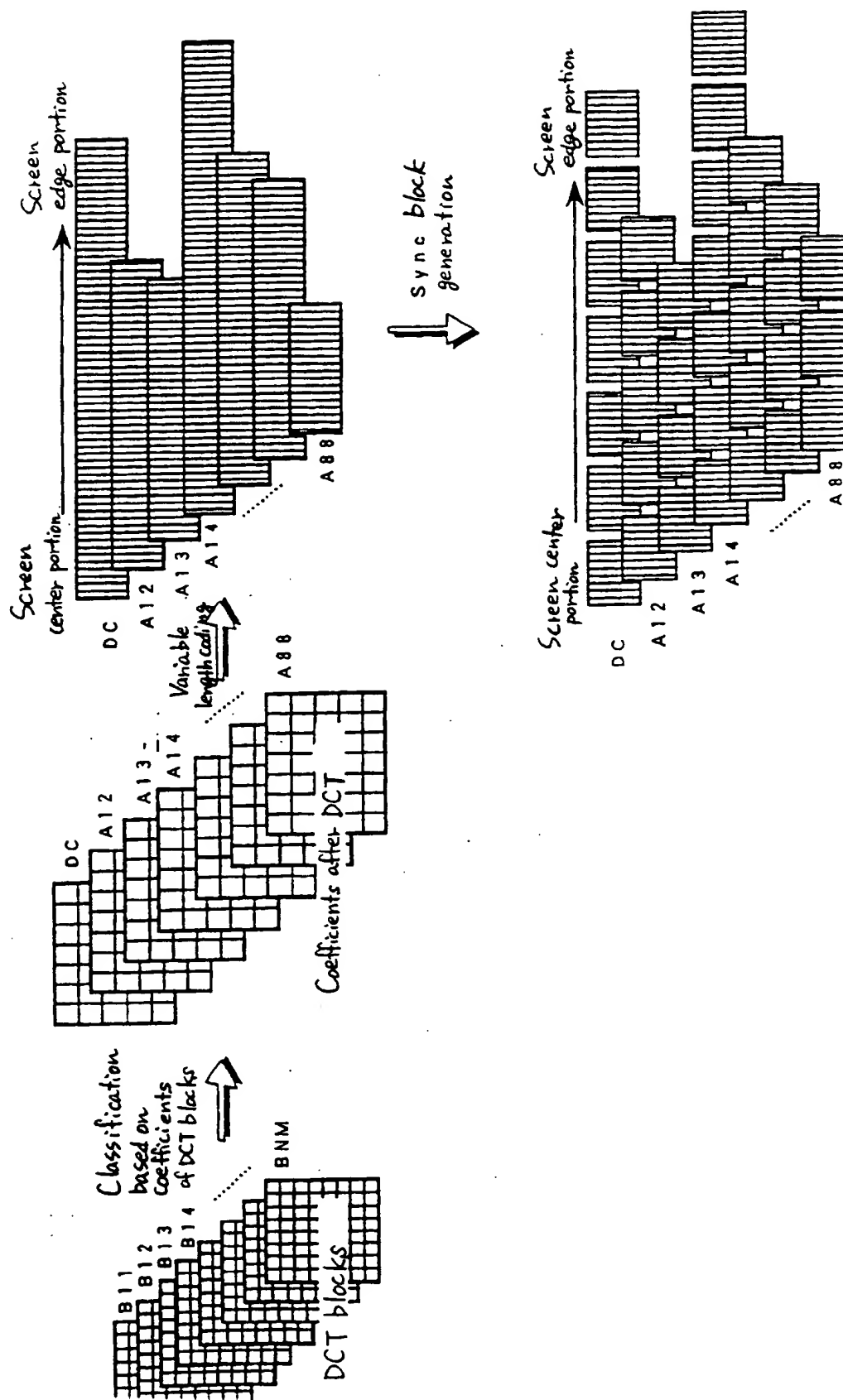


Fig. 29A

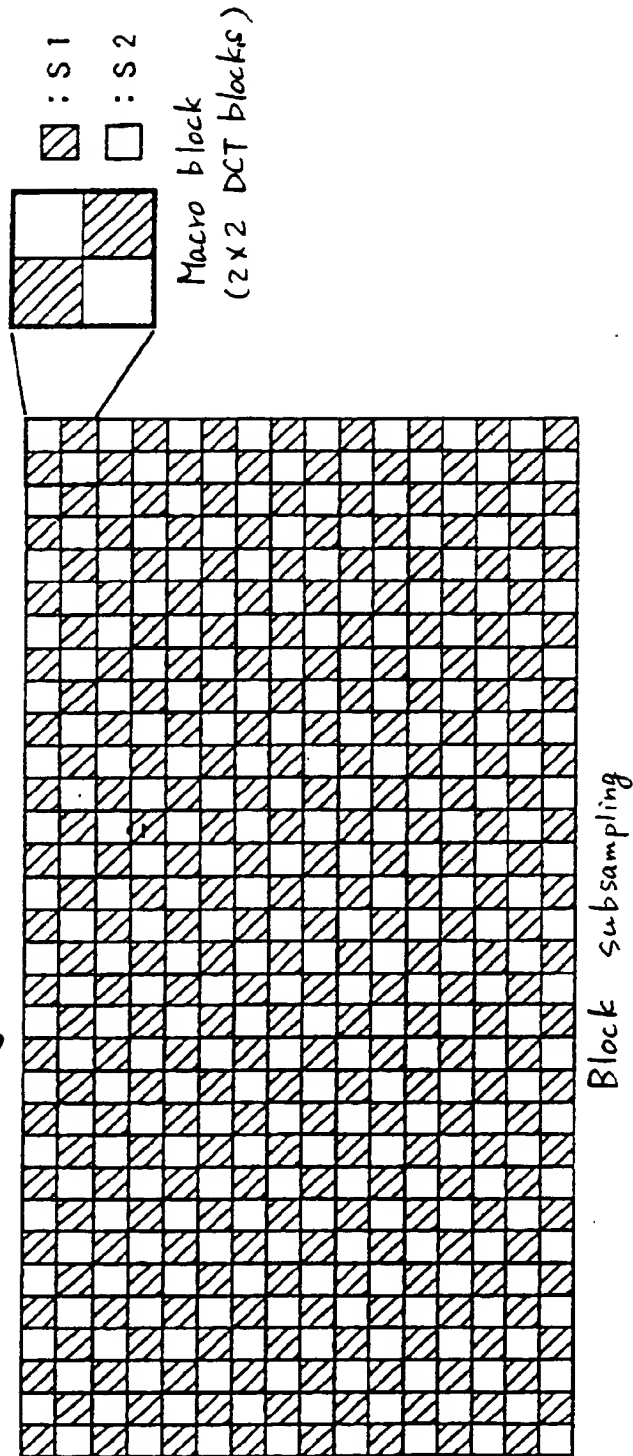


Fig. 29B

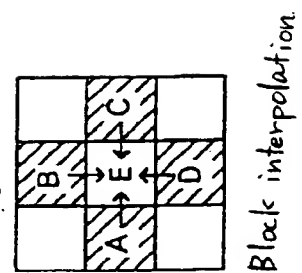


Fig. 30B

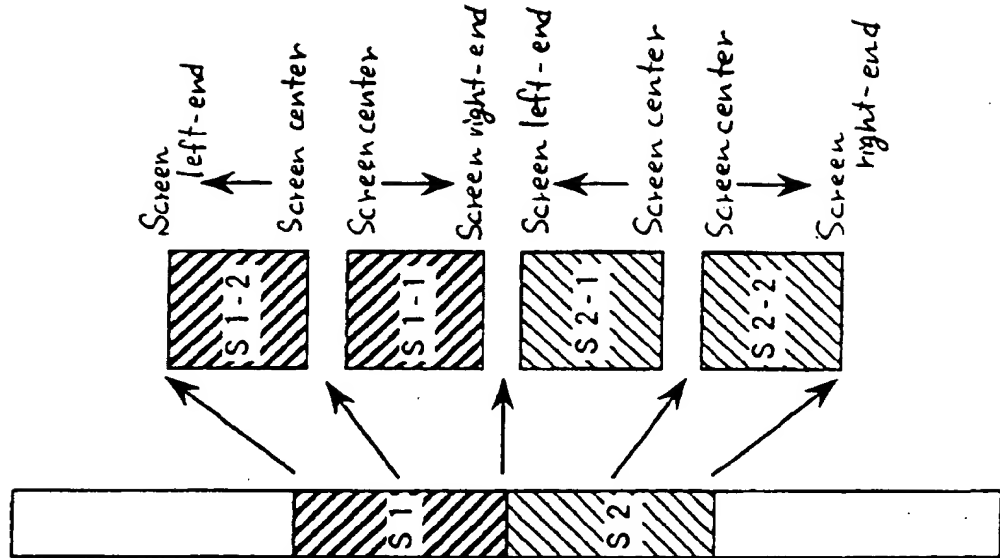


Fig. 30A

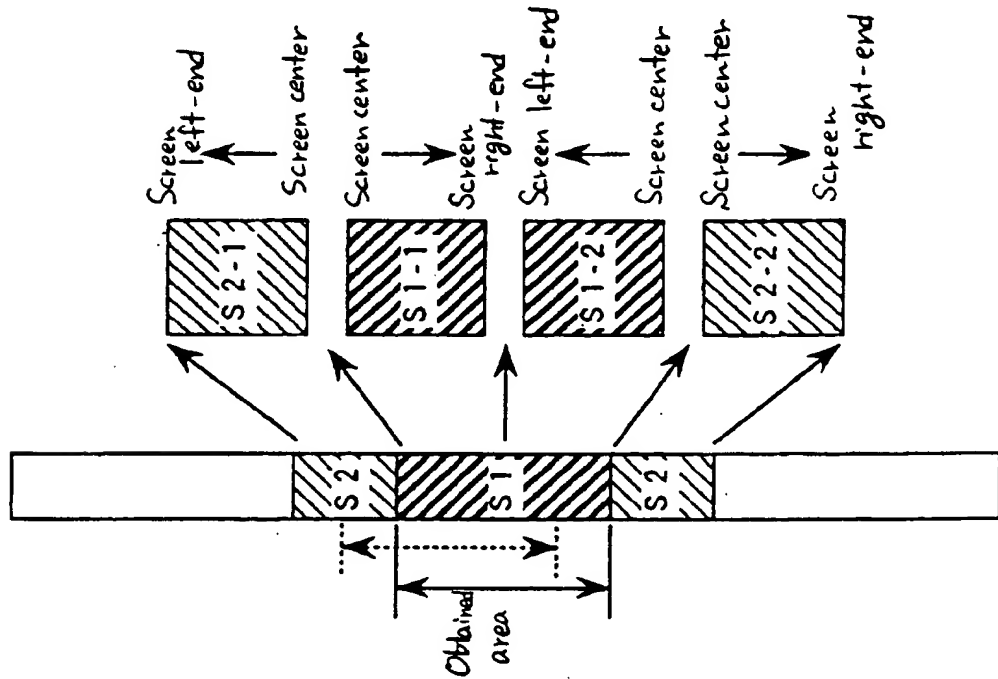




Fig. 31A

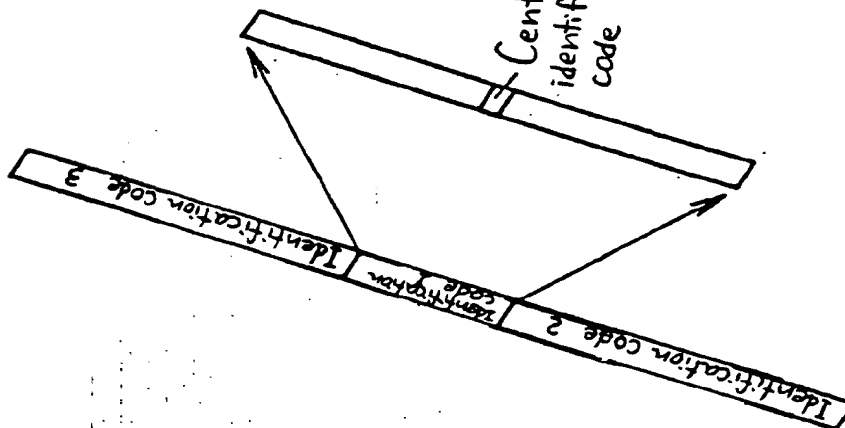


Fig. 31B

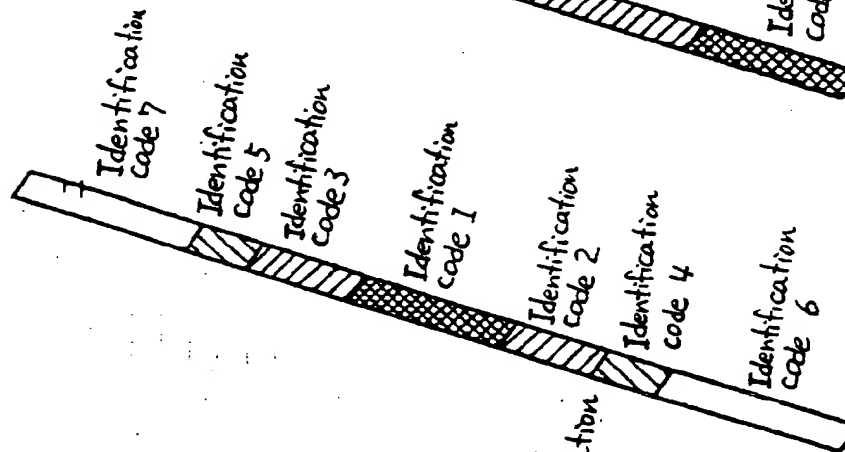


Fig. 31C

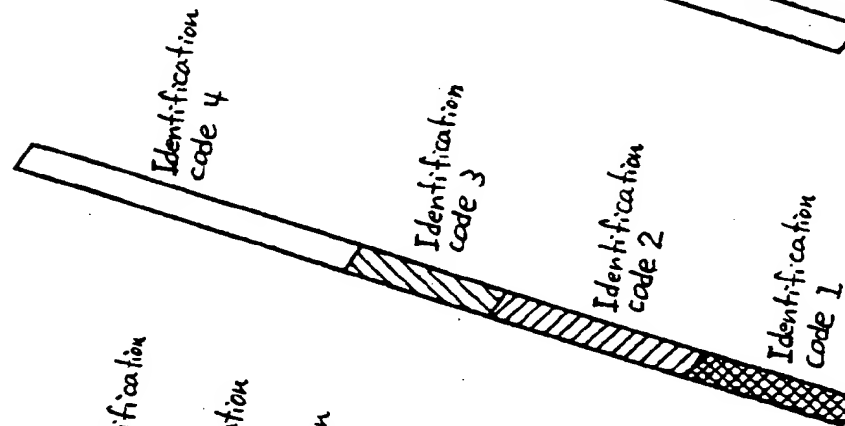
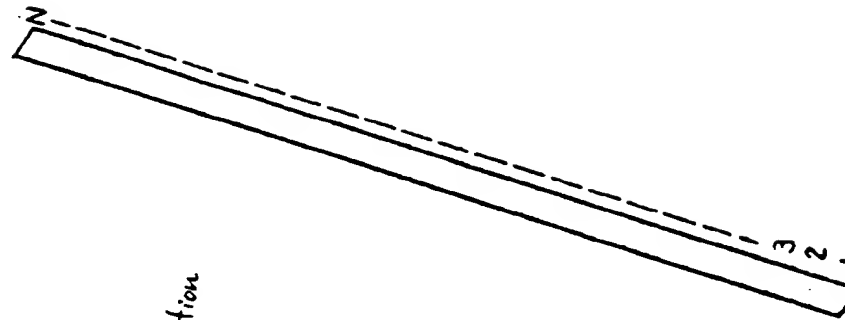


Fig. 31D



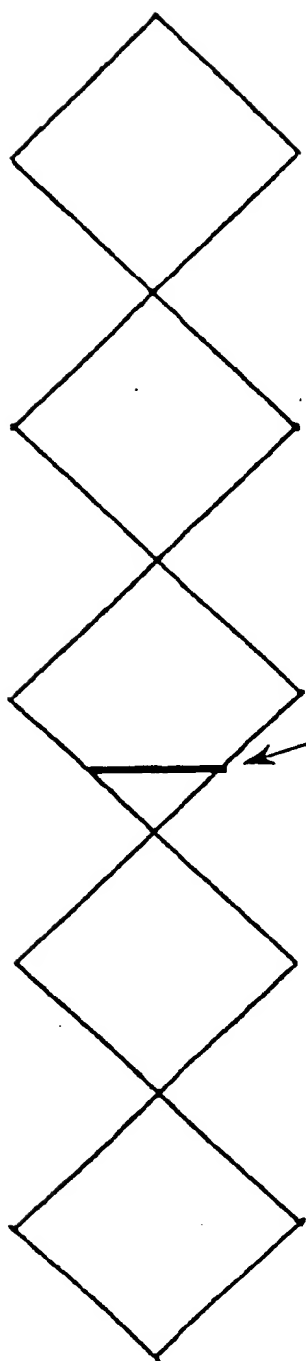


Fig. 32A

Reproduction  
envelope

Center identification code

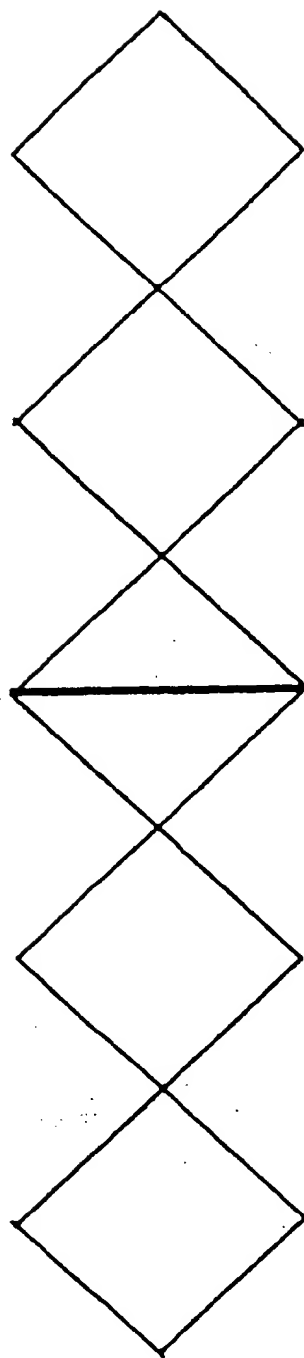


Fig. 32B

Reproduction  
envelope

Fig. 33

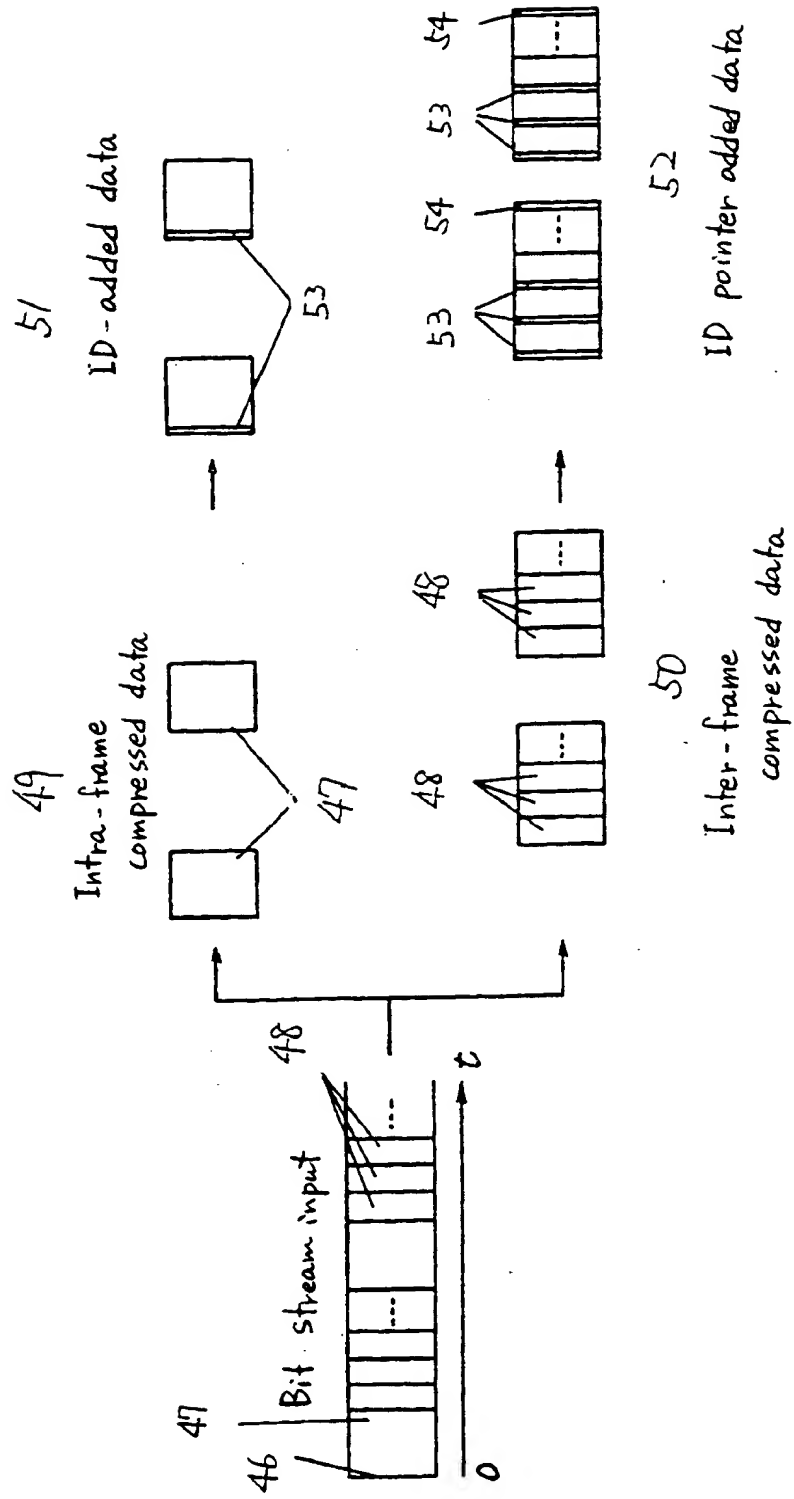


Fig. 34

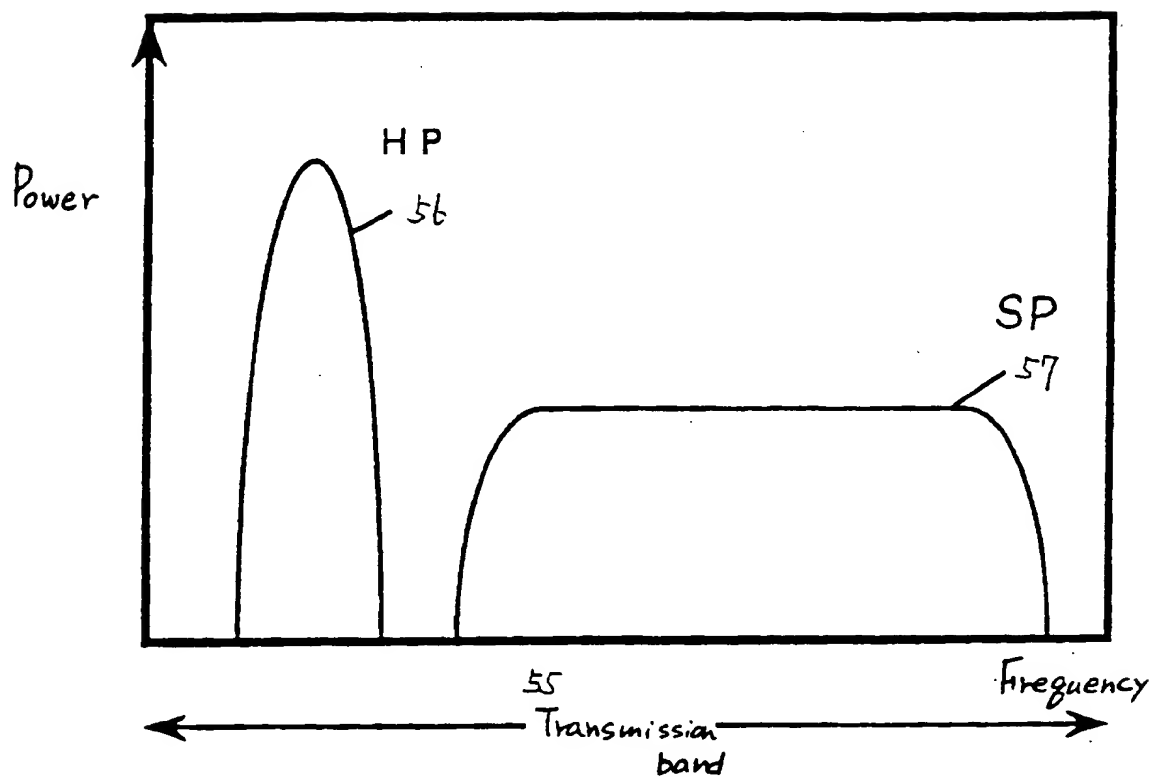


Fig.35A

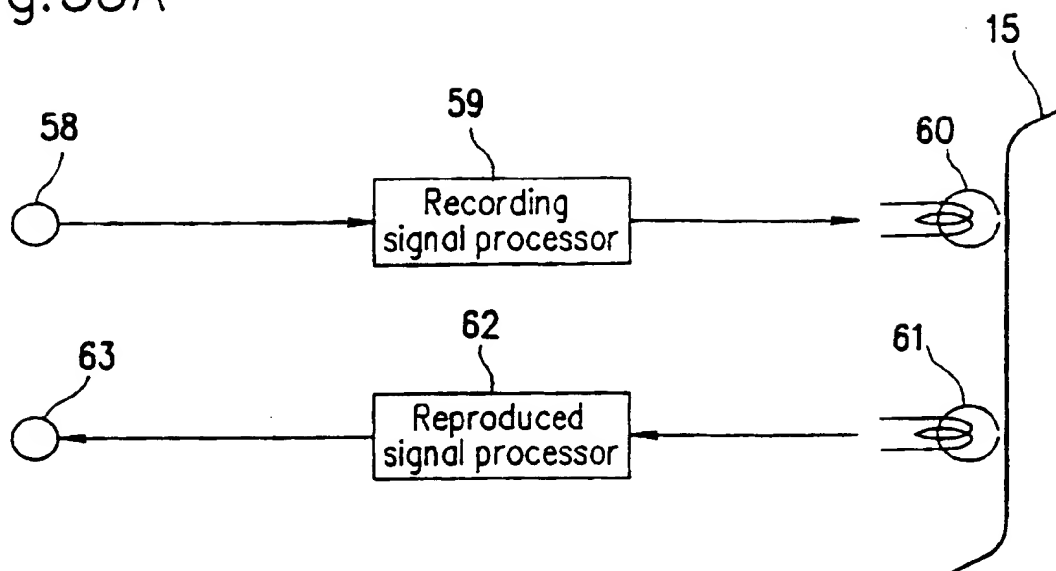


Fig.35B

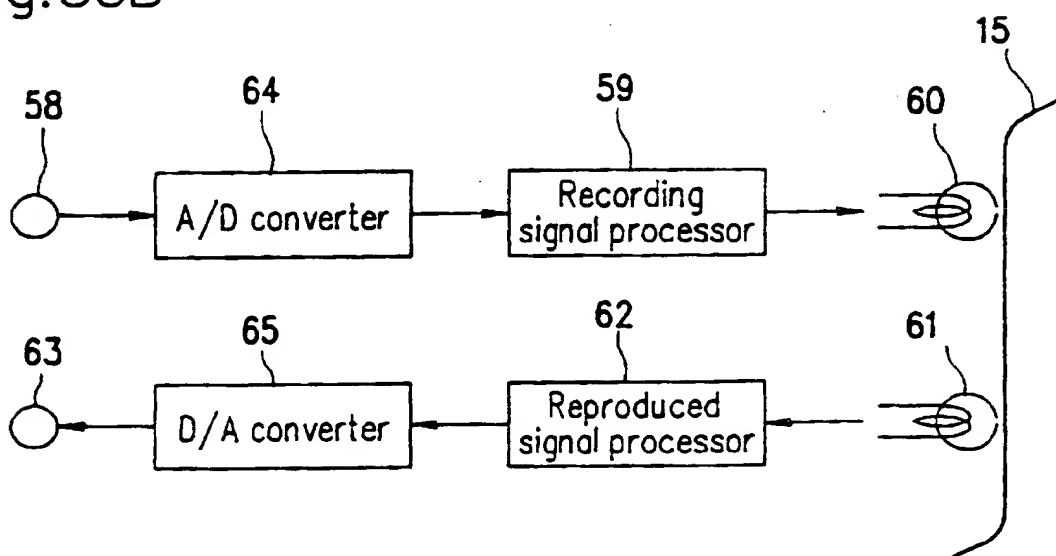


Fig. 36

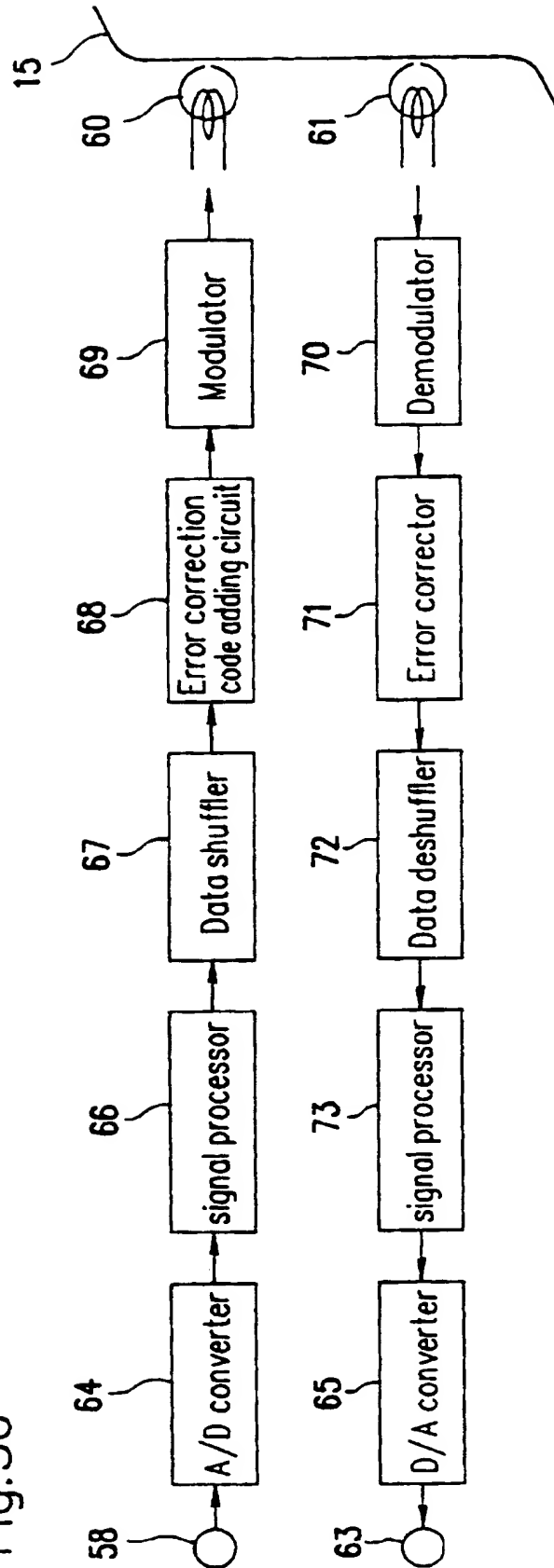


Fig. 37

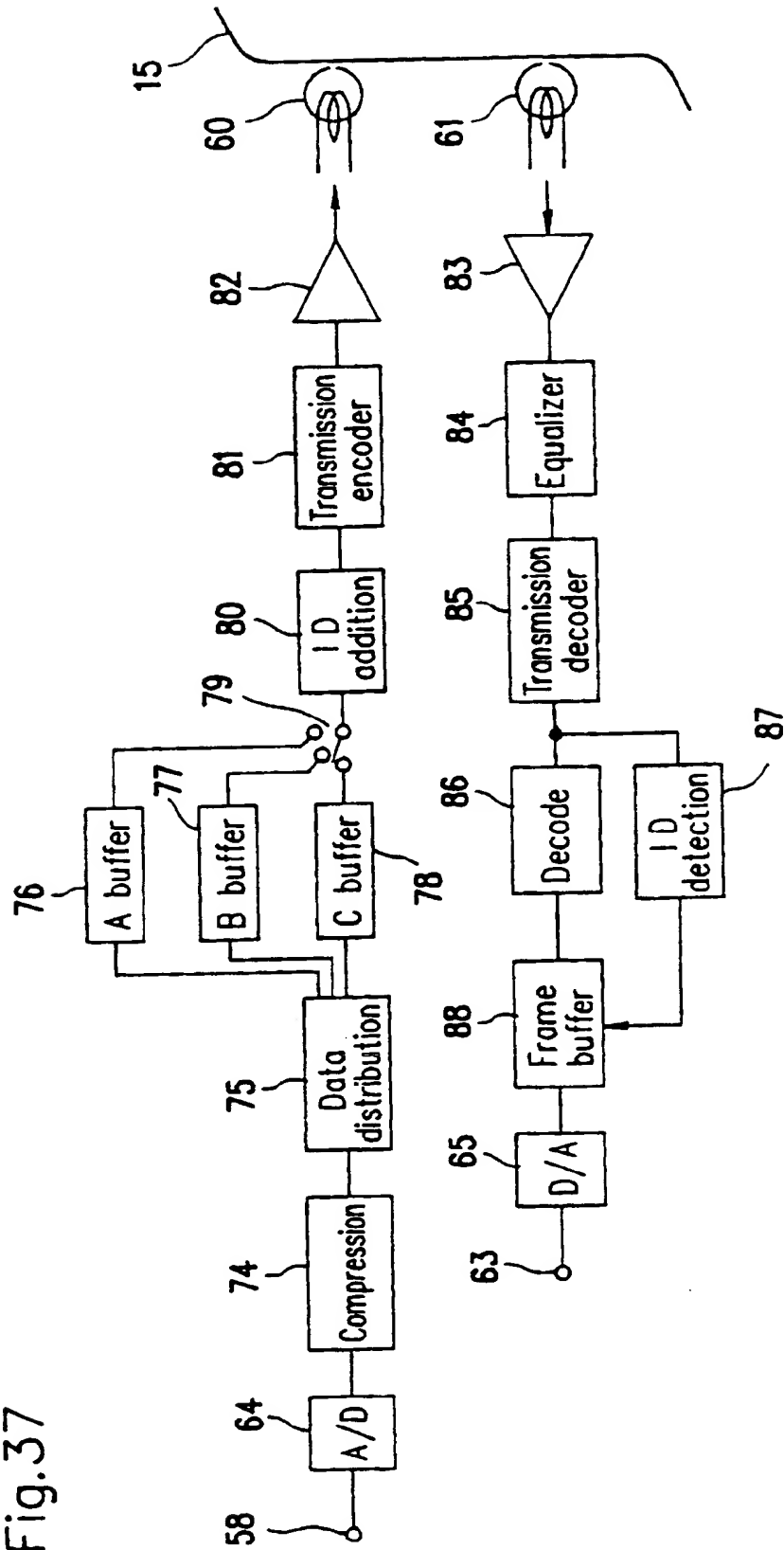


Fig. 38

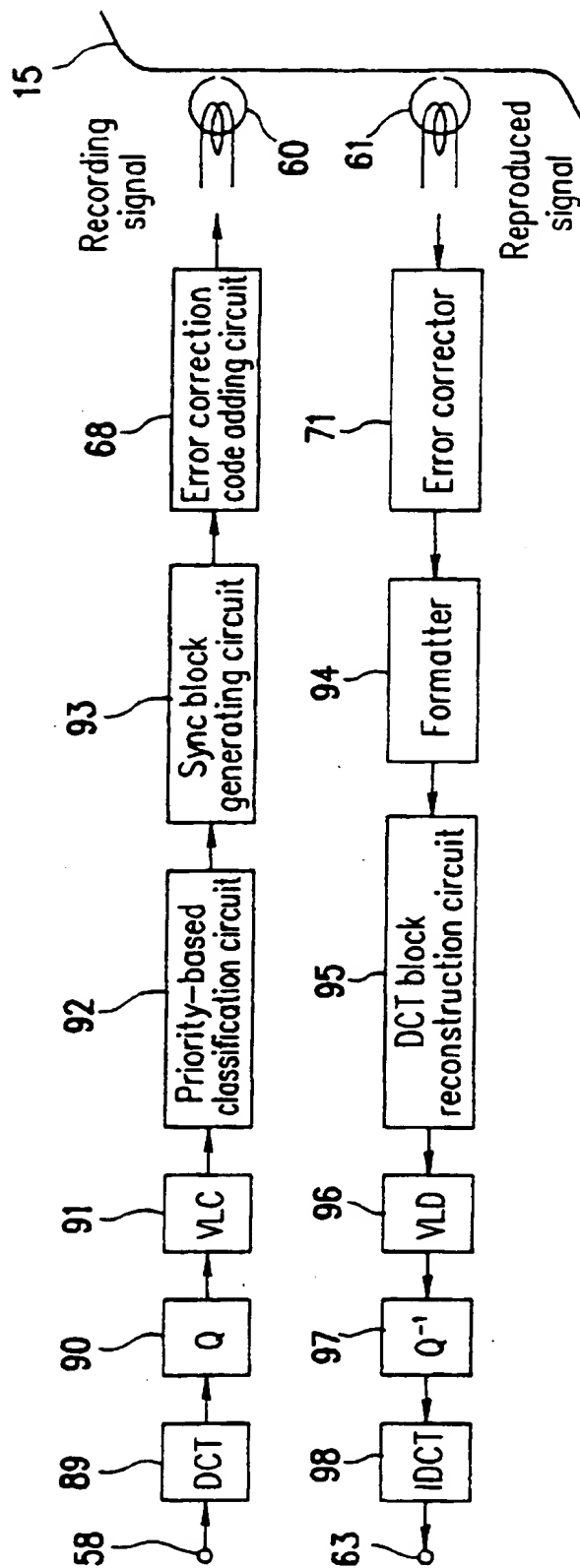




Fig. 39

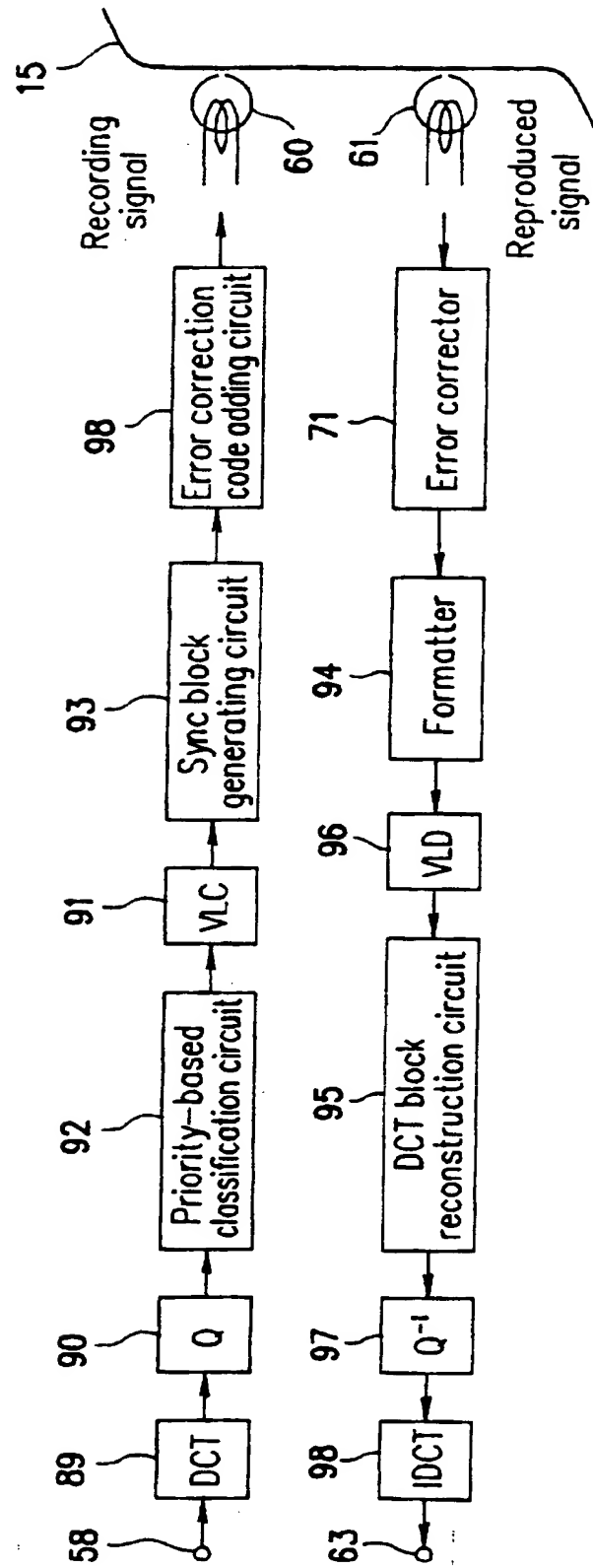


Fig. 40

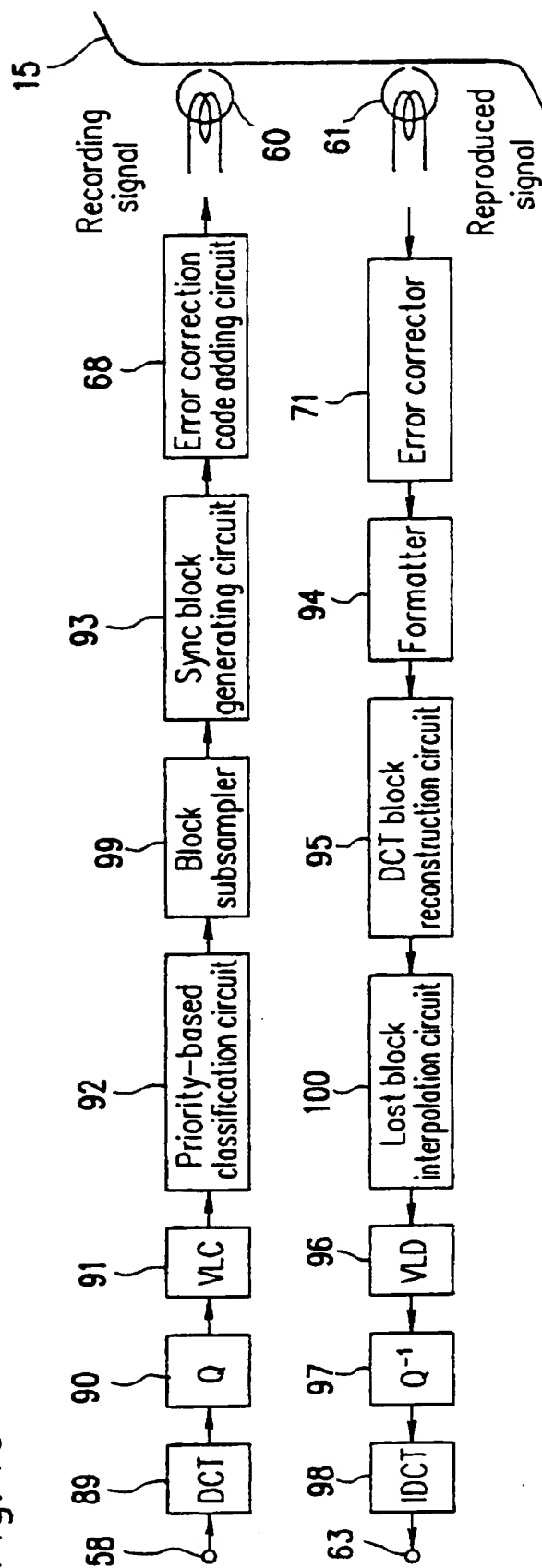


Fig. 41

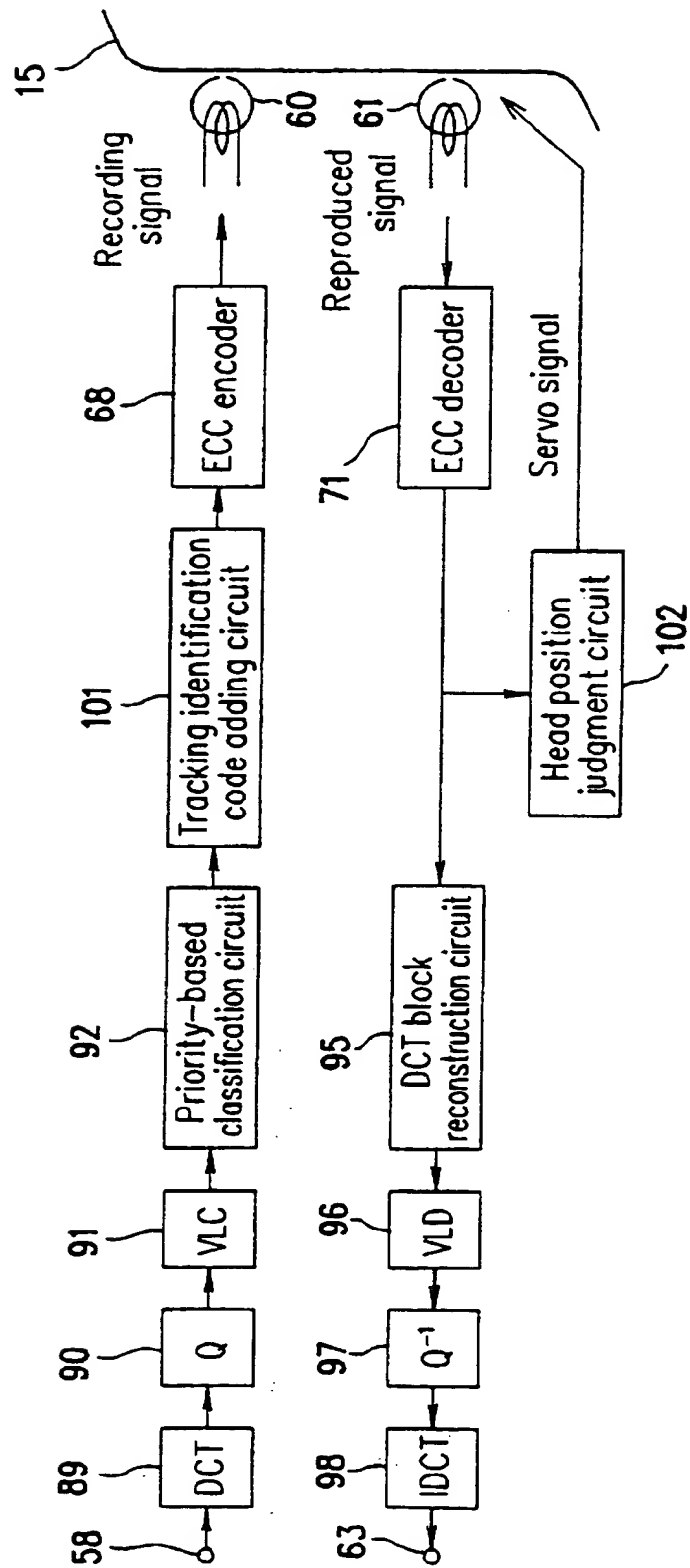


Fig. 42

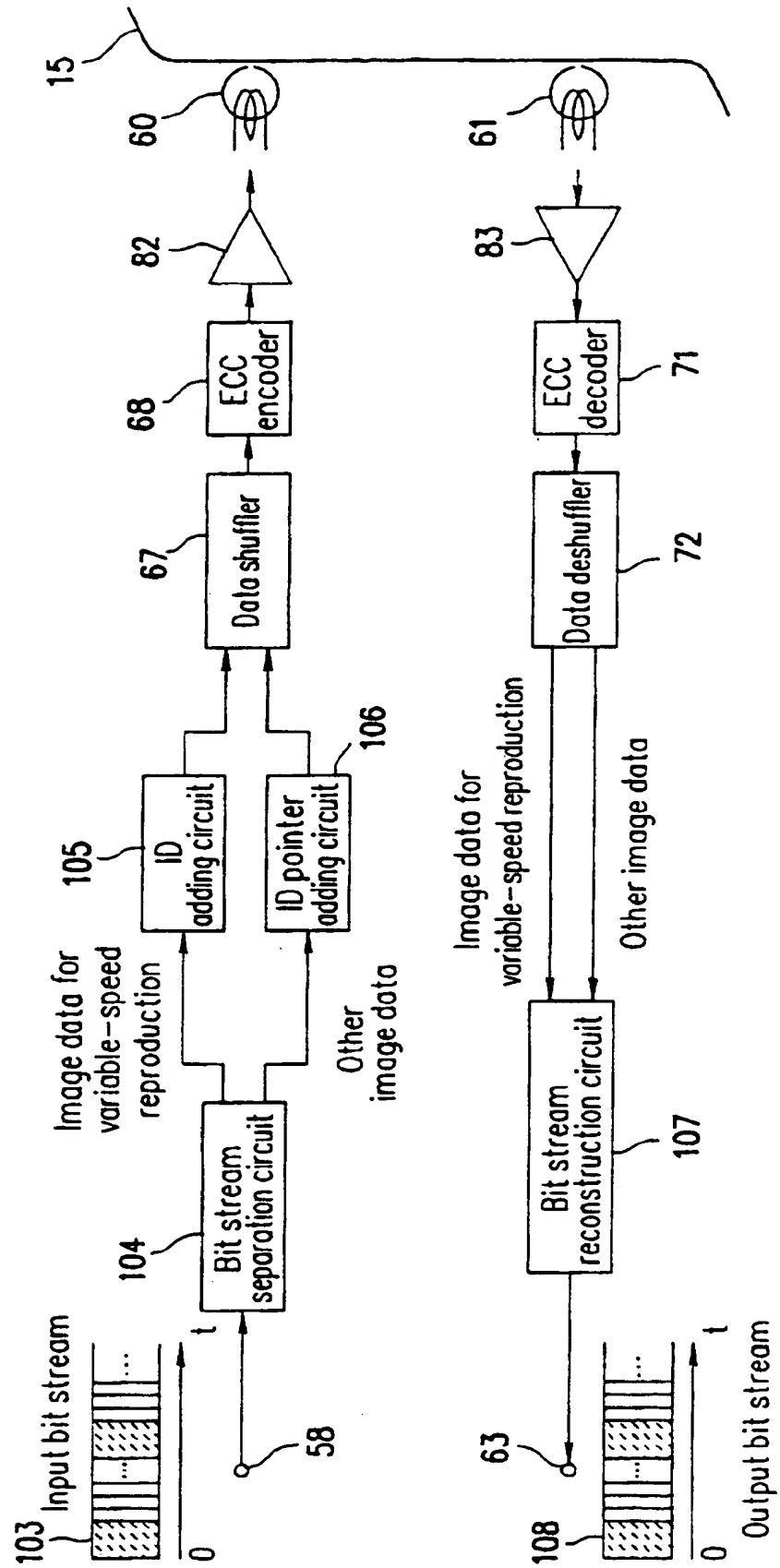


Fig. 43

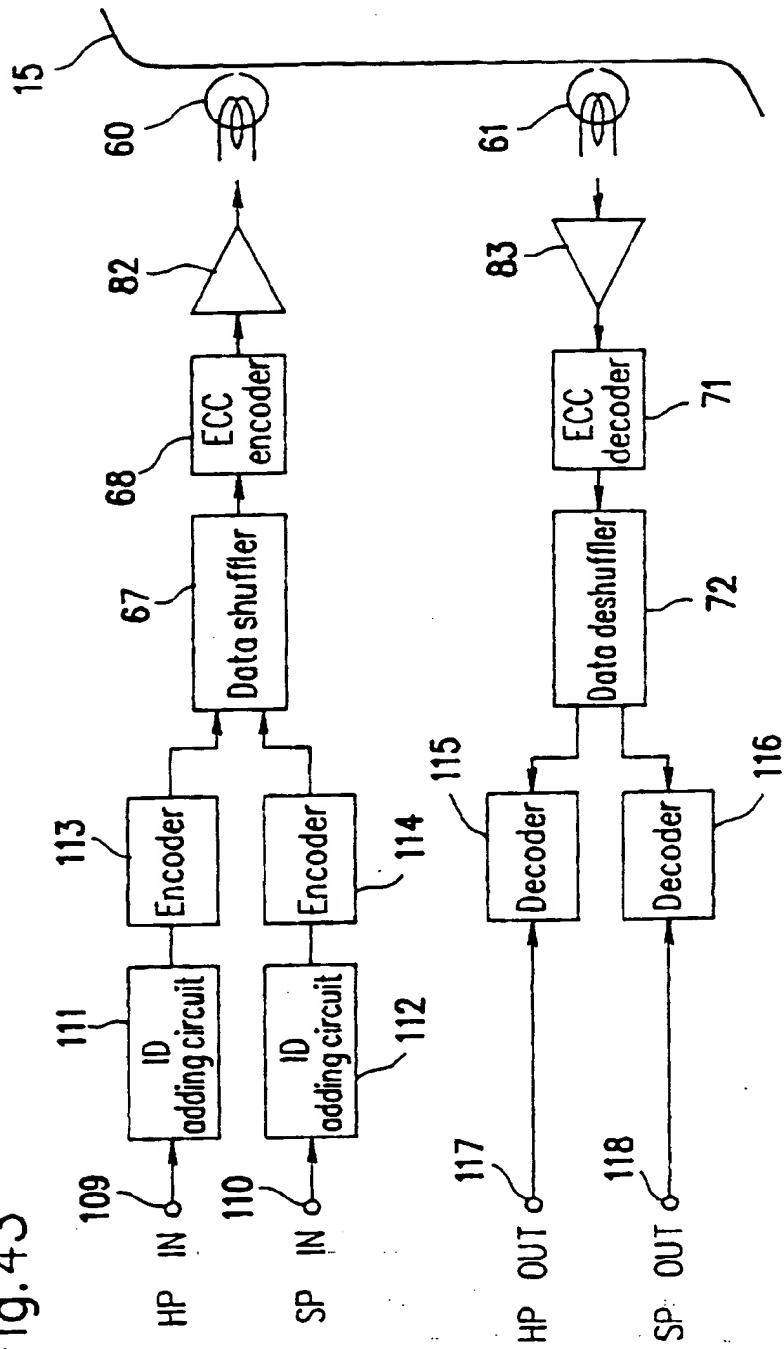


Fig. 44

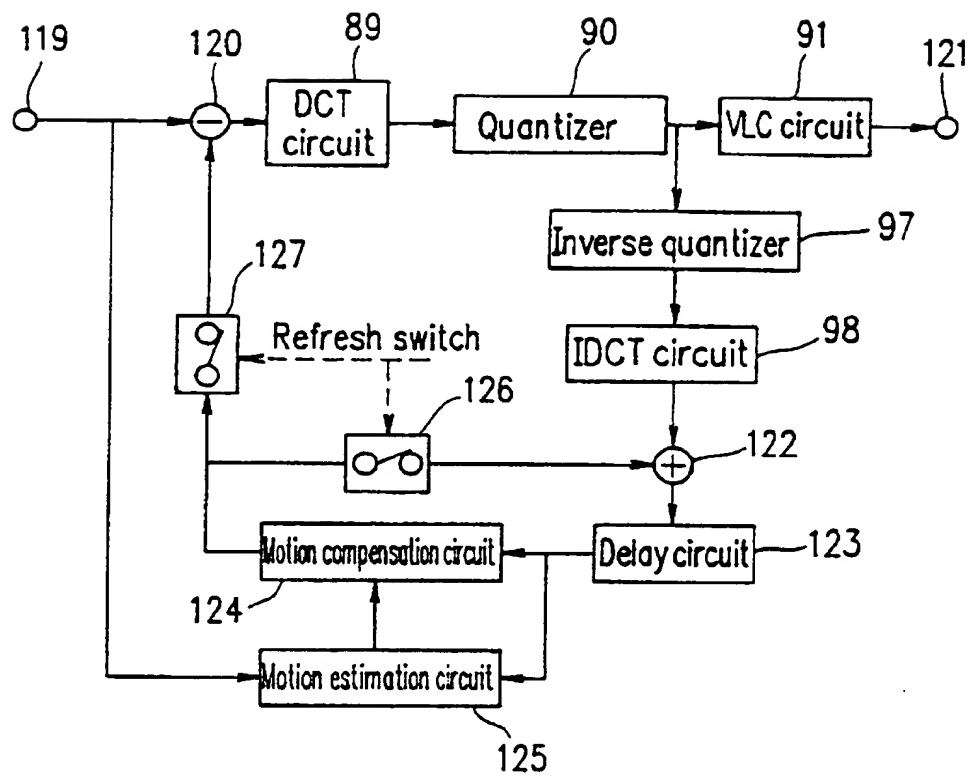


Fig. 45A

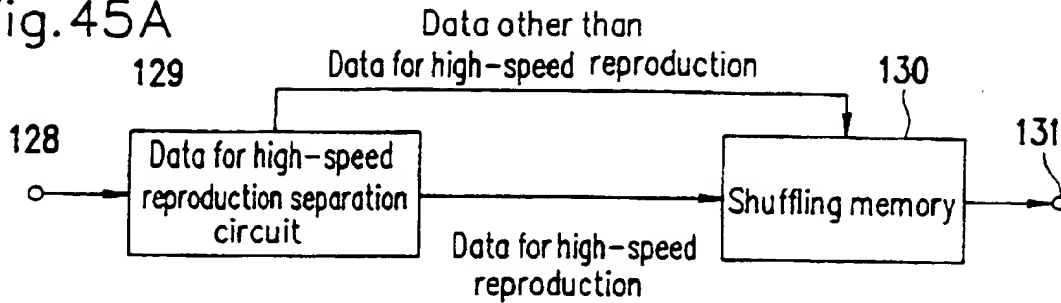


Fig. 45B

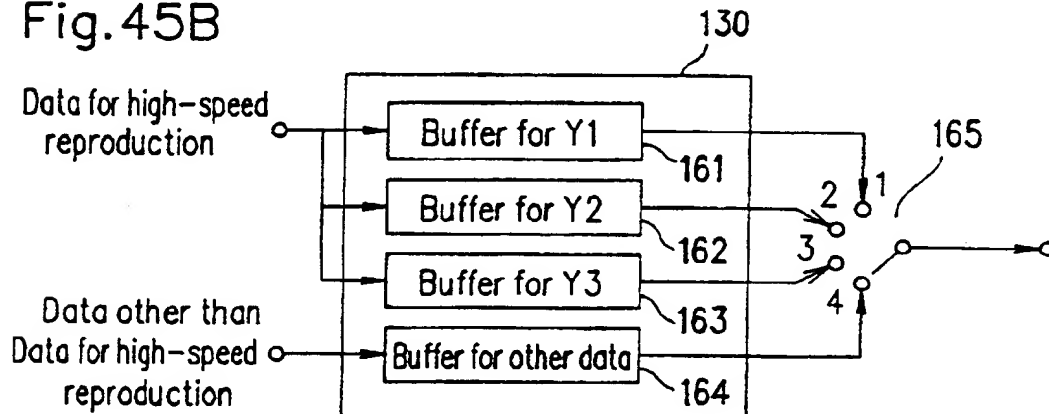


Fig. 45C

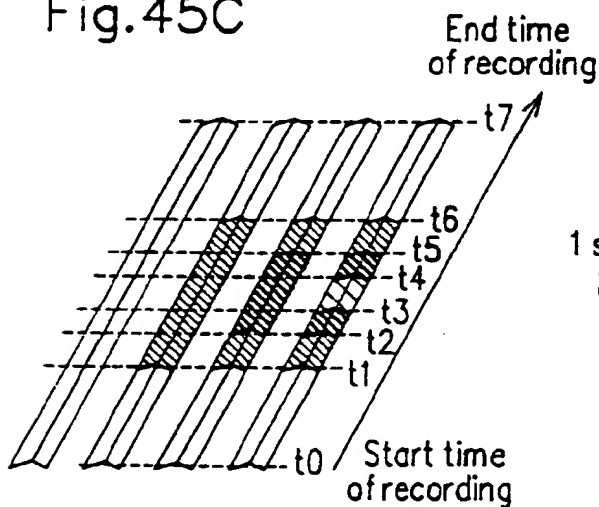


Fig. 45D

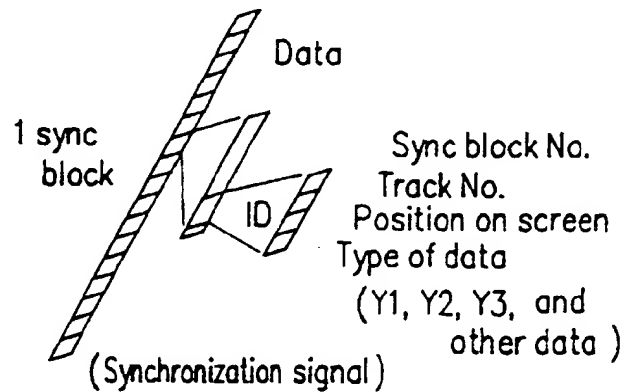


Fig. 45E

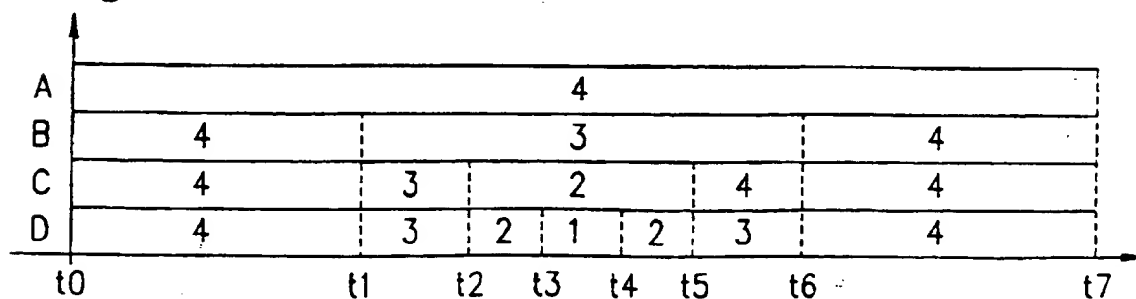


Fig. 46

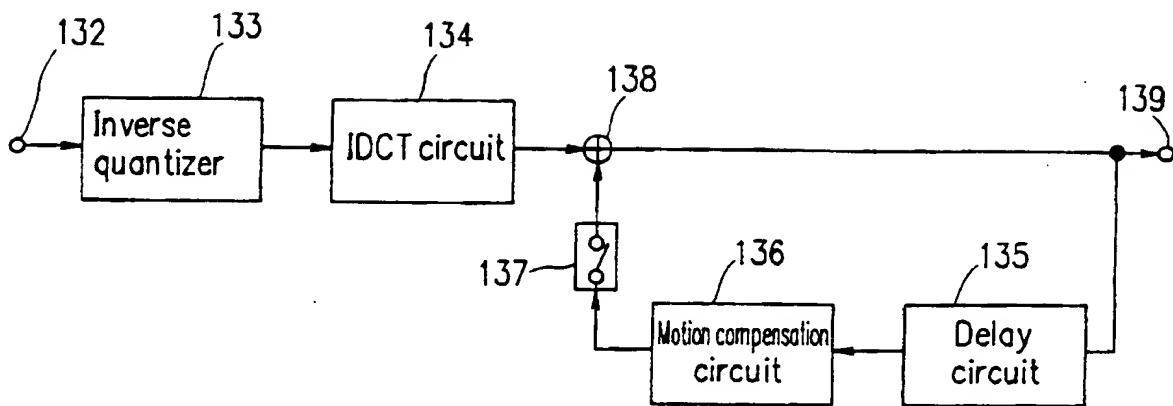




Fig.47A

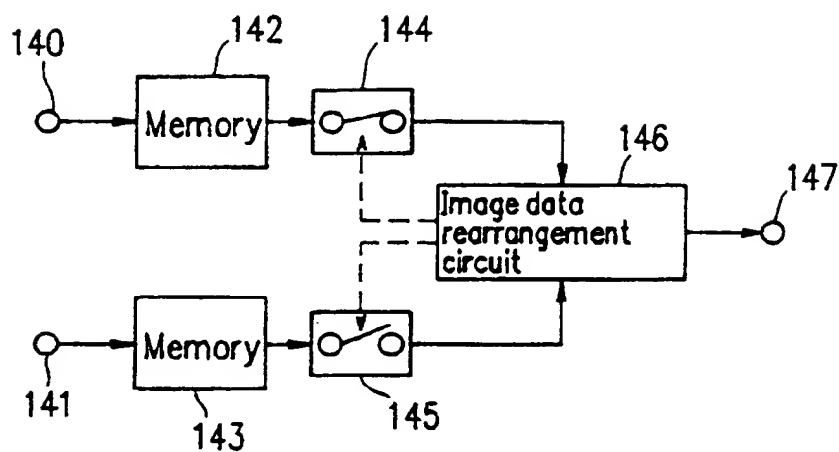


Fig.47B

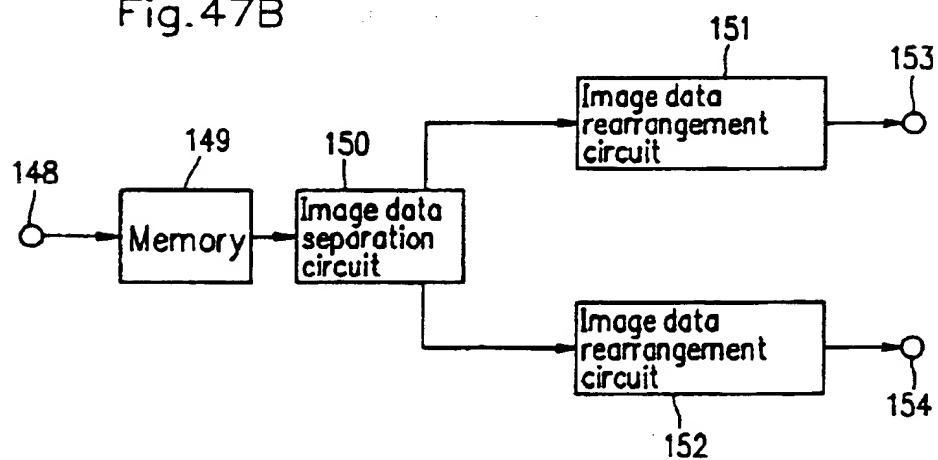
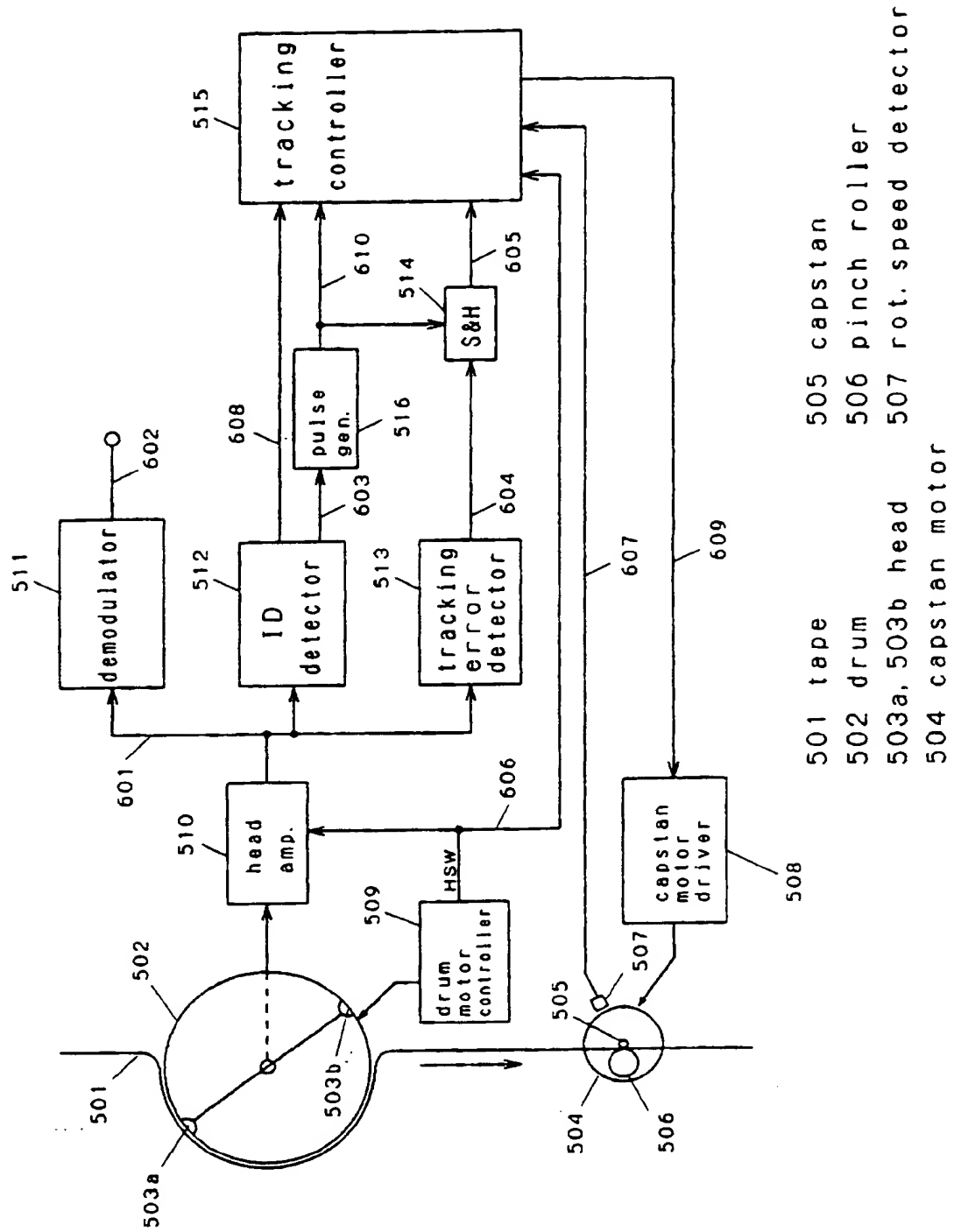


Fig. 48



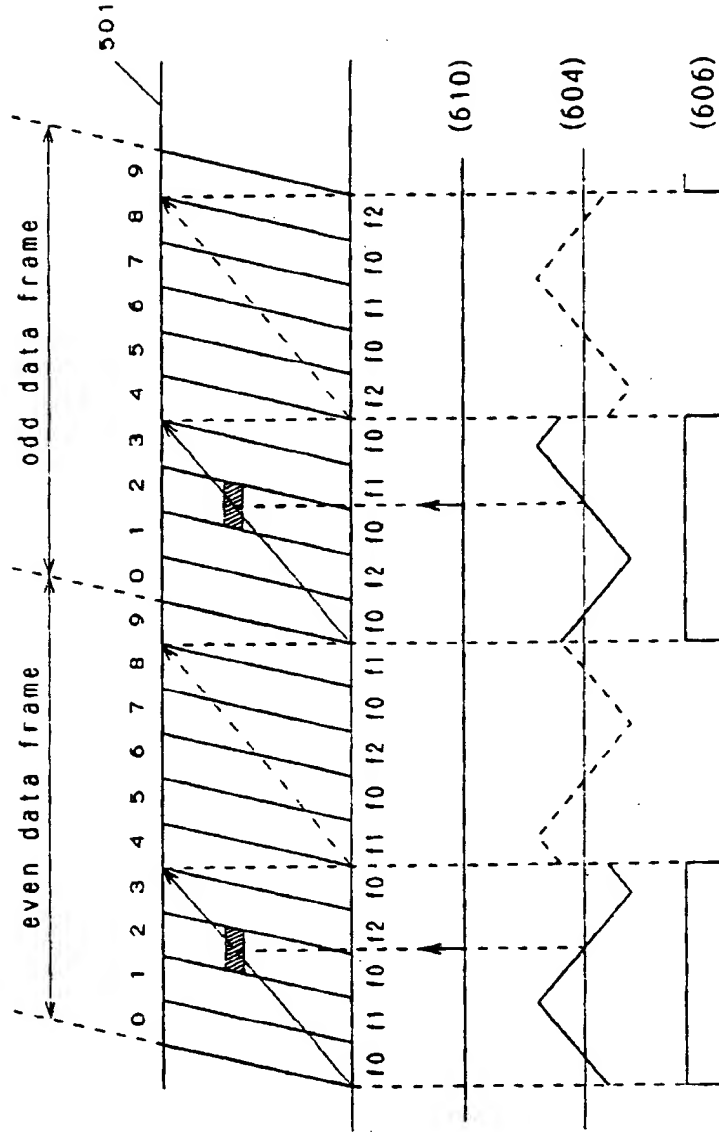


Fig. 49A

Fig. 49B

Fig. 49C

Fig. 49D

Fig. 50

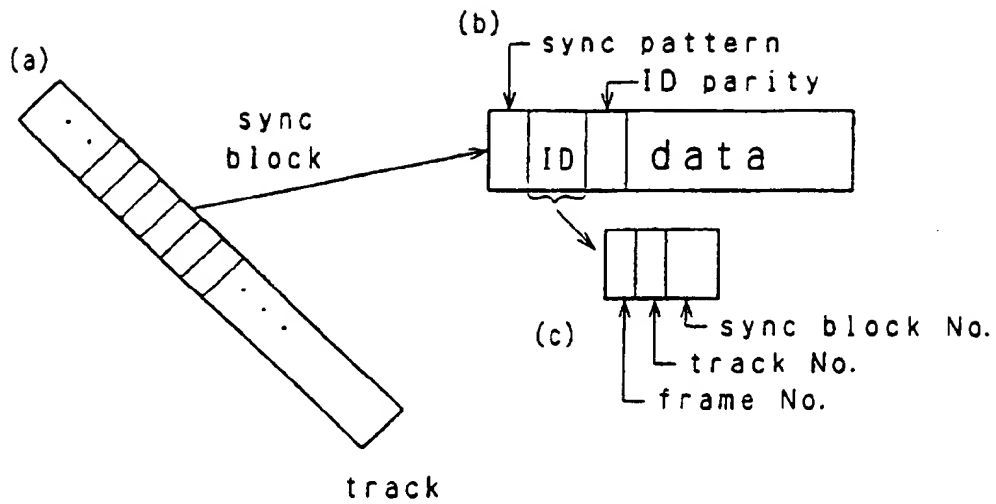


Fig. 51

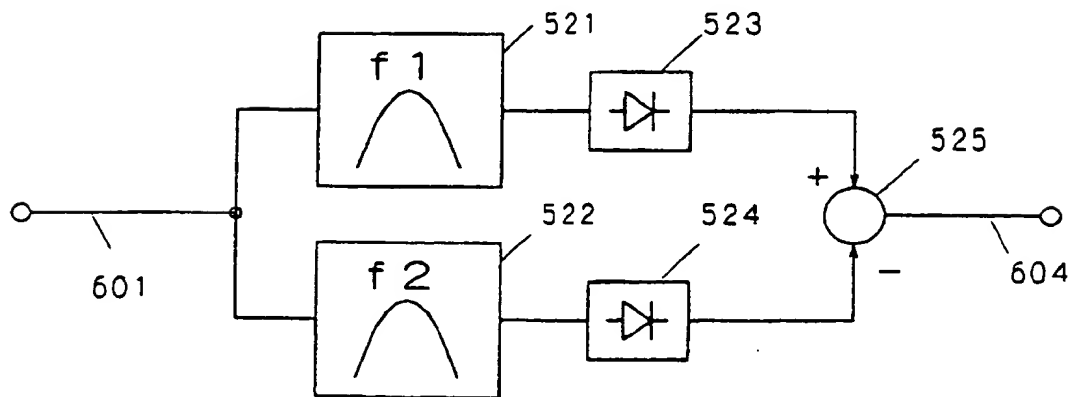


Fig. 52

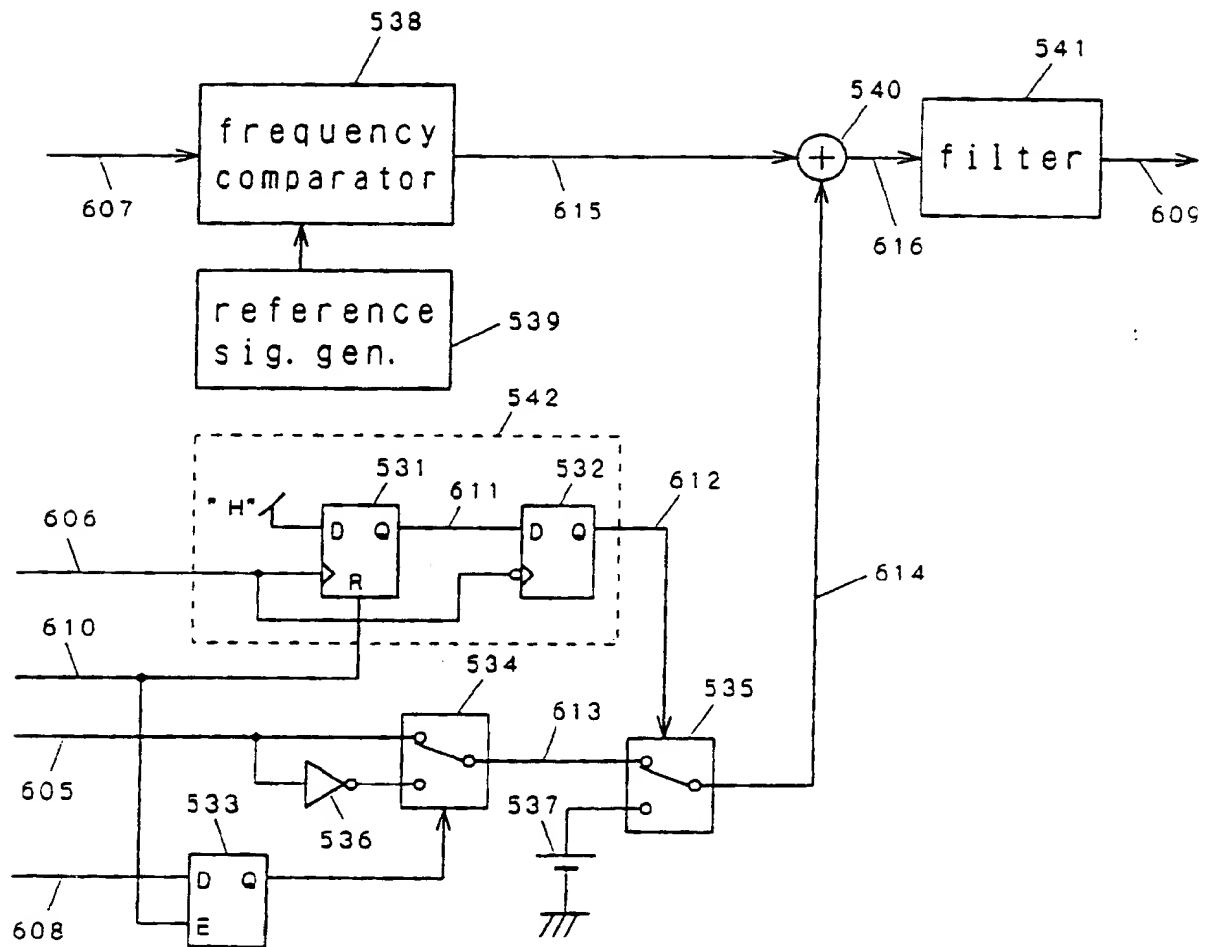


Fig. 53

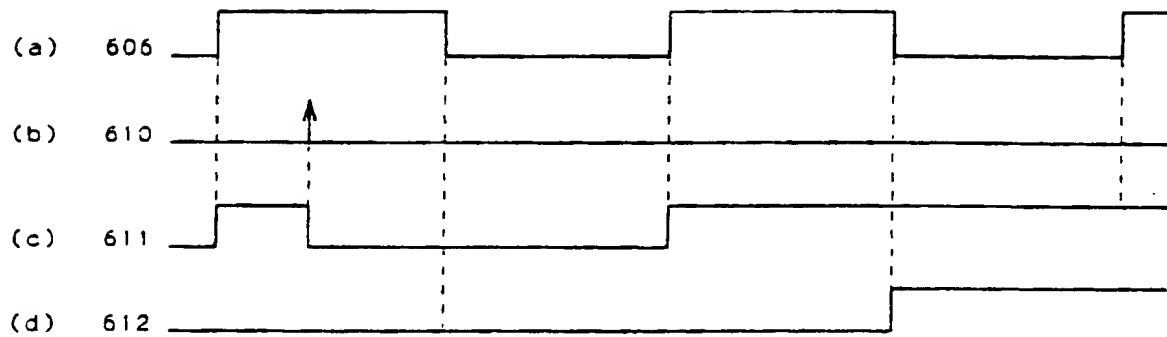


Fig. 54

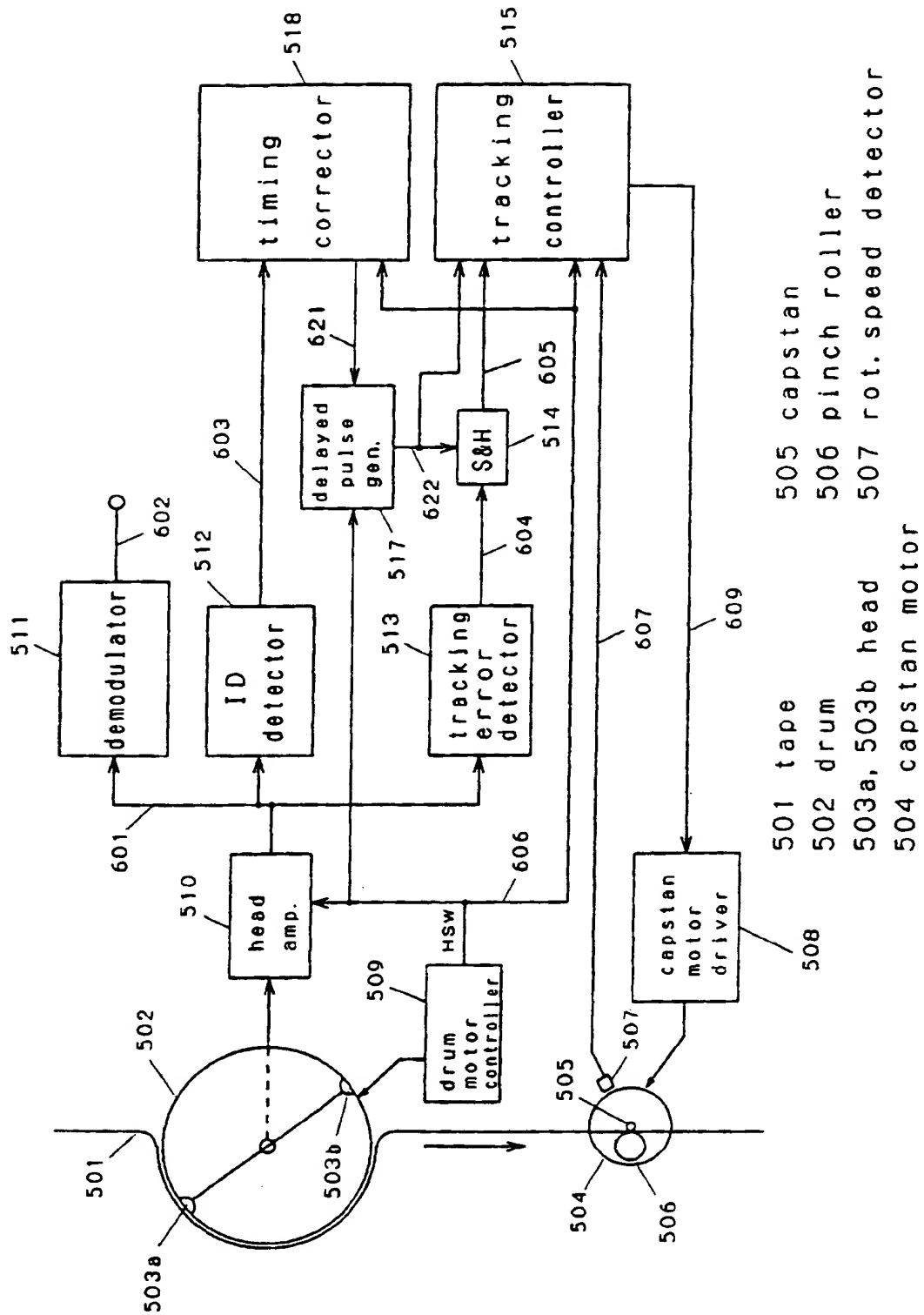


Fig. 55

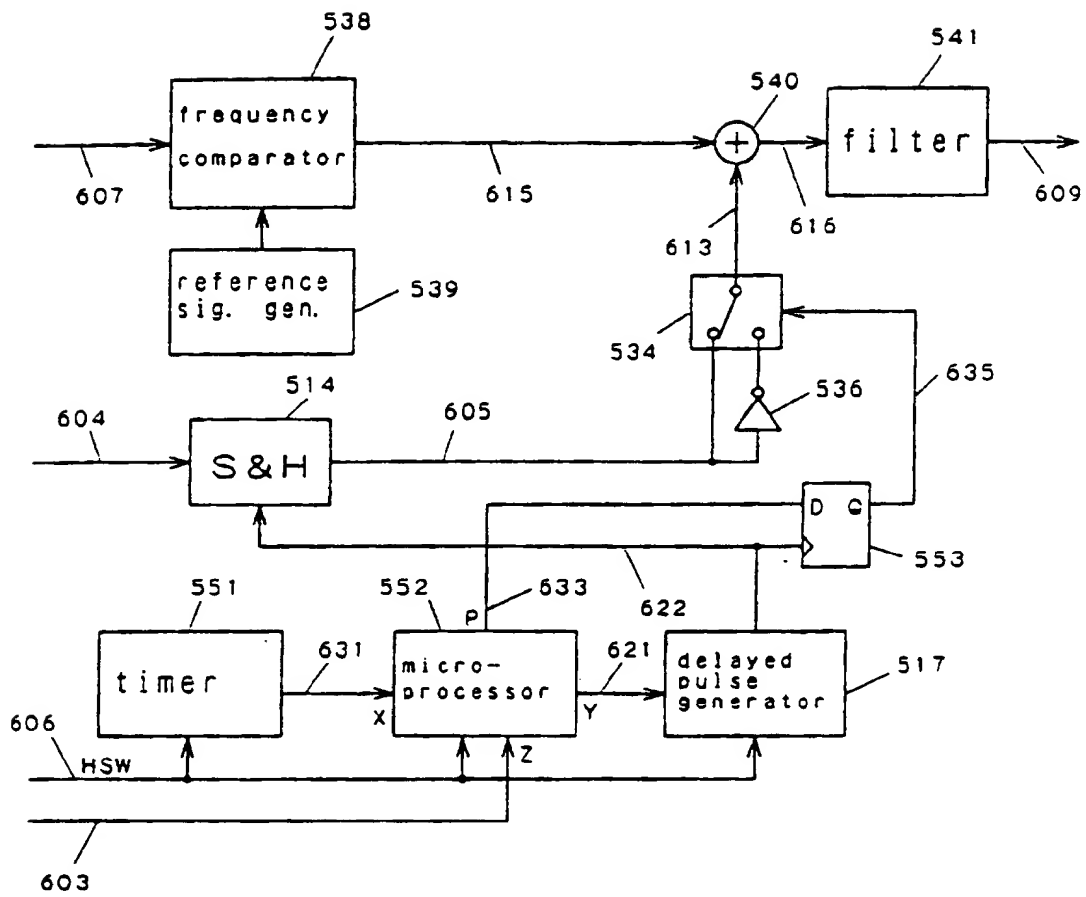
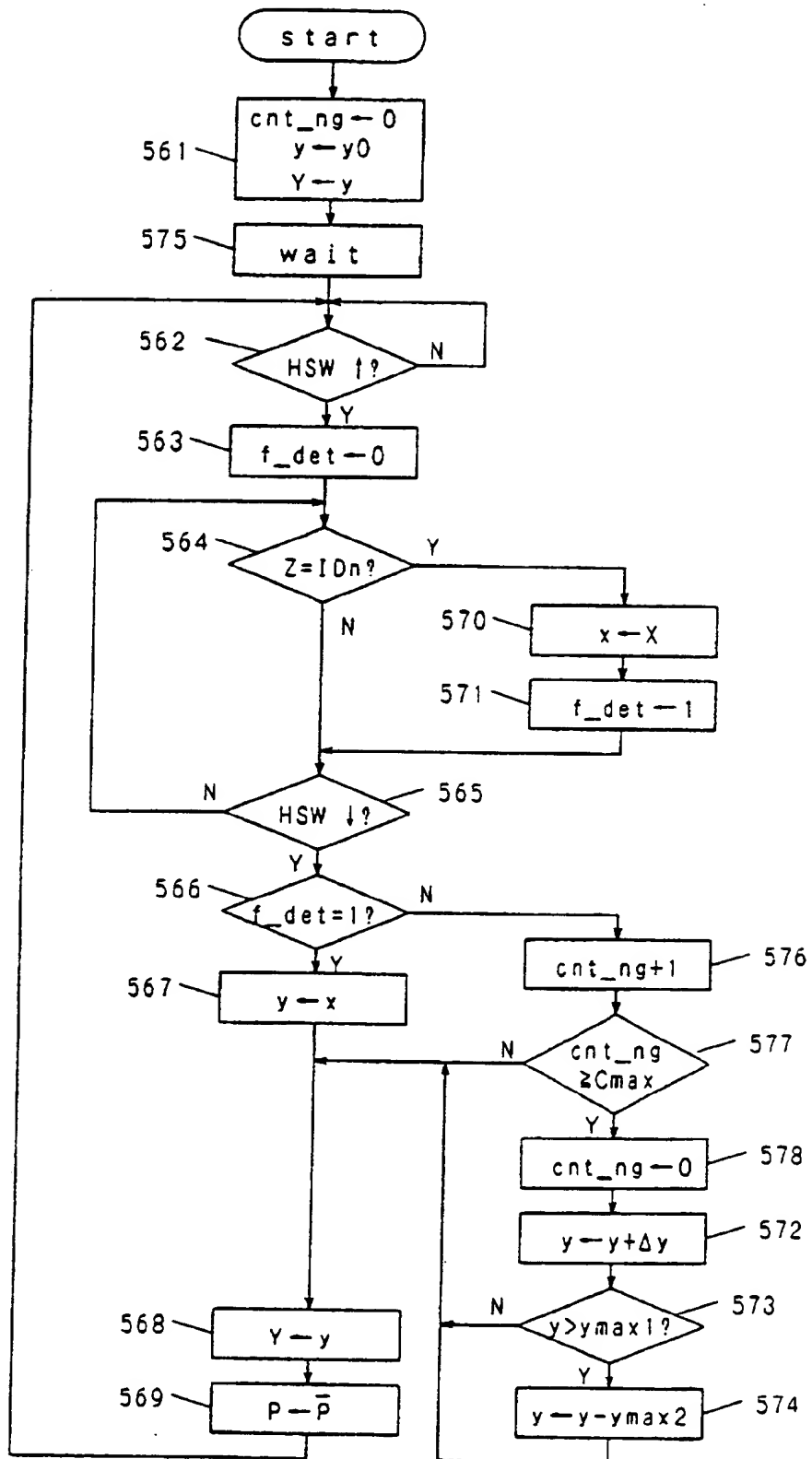
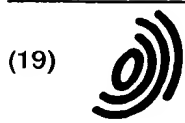




Fig. 56





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H04N 5/92, H04N 5/783,  
H04N 5/94

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**05.10.1994 Bulletin 1994/40**

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**17.06.1993 JP 145889/93**  
**01.07.1993 JP 163417/93**  
**30.07.1993 JP 189977/93**  
**06.08.1993 JP 195876/93**  
**09.11.1993 JP 279522/93**

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(72) Inventors:

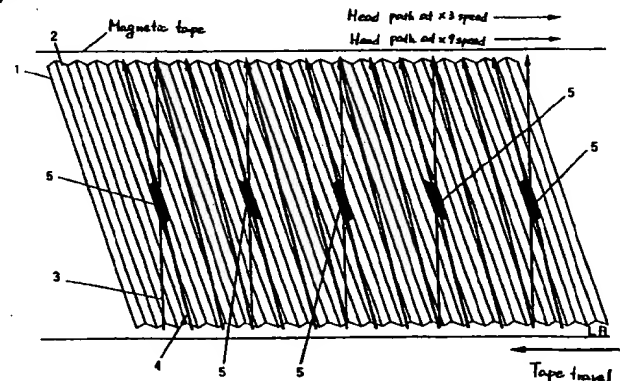
- Hamamoto, Yasuo  
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- Morimoto, Kenji  
Osaka-shi, Osaka (JP)
- Kohno, Katsufumi  
Sakai-shi, Osaka (JP)
- Sakakibara, Yoshio  
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- Gotou, Makoto  
Nishinomiya-shi, Hyogo-ken (JP)

(74) Representative: **Marx, Lothar, Dr.**  
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**Stuntzstrasse 16**  
**81677 München (DE)**

(54) **Signal recording and reproducing apparatus**

(57) The disclosed apparatus for recording and reproducing data includes: a recording medium traveling section for making a recording medium to travel in a first direction; a rotating drum which rotates with an angle with respect to the first direction, the rotating drum having a head used for recording and reproducing the data; a recording section for recording first data of the data onto a first portion (5) of the recording medium, the first portion being commonly passed by the head at three or more predetermined speeds; and a reproducing section for reproducing the first data which is recorded at least on the first portion of the recording medium at each of the three or more predetermined speeds.

**Fig. 1**



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## EUROPEAN SEARCH REPORT

Application Number  
EP 94 10 3038

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	EP-A-0 508 779 (MATSUSHITA ELECTRIC IND CO LTD) 14 October 1992 * claims 1,2; figure 1 * * column 6, line 2 - column 7, line 20 * ---	36-38	G11B5/008 G11B20/10 H04N5/92 H04N5/783 H04N5/94
Y	US-A-4 920 435 (YAMAZAKI SHOHEI) 24 April 1990 * claim 1 * * column 7, line 26 - column 9, line 18 * * column 7, line 3 - line 31 * * column 4, line 57 - column 5, line 40 * * column 1, line 42 - line 57 * * abstract; figures 1A,1B,5 * ---	36-38	
Y	EP-A-0 436 114 (SONY CORP) 10 July 1991 * claims 1,2; figures 4A,8 * * column 9, line 24 - column 12, line 46 * * abstract * ---	36-38	
Y,P	EP-A-0 564 234 (MATSUSHITA ELECTRIC IND CO LTD) 6 October 1993 * column 5, line 49 - column 8, line 15; figures 1,3-6 * ---	36-38	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
Y	PATENT ABSTRACTS OF JAPAN vol. 017, no. 095 (P-1493), 25 February 1993 & JP-A-04 291049 (MATSUSHITA ELECTRIC IND CO LTD), 15 October 1992, * abstract * & US-A-5 321 557 (SHIMOTASHIRO MASAFUMI ET AL.) 14 June 1994 * figures 1,2,6,7 * * column 4, line 53 - column 65 * * column 7, line 21 - column 10, line 46 * --- -/--	36-38	H04N G11B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 July 1996	Examiner Schiwy-Rausch, G
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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Application Number  
EP 94 10 3038

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y,P	EP-A-0 579 411 (MATSUSHITA ELECTRIC IND CO LTD) 19 January 1994 * figure 1 * * column 5, line 7 - line 56 * * column 3, line 14 - column 4, line 2 * ---	36-38	
A	US-A-4 338 631 (OTA YOSHIHIKO) 6 July 1982 * abstract; figures 1,4A * * column 3, line 34 - line 64 * * column 6, line 32 - column 7, line 31 * ---	1,3-5,17	
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 267 (E-1217), 16 June 1992 & JP-A-04 061523 (MATSUSHITA ELECTRIC IND CO LTD), 27 February 1992, * abstract * ---	1,6,7, 17,22,23	
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 259 (E-1215), 11 June 1992 & JP-A-04 056577 (MATSUSHITA ELECTRIC IND CO LTD), 24 February 1992, * abstract * ---	1,4,25	
A	US-A-4 864 430 (YOSHIMURA KATSUJI ET AL) 5 September 1989 * abstract; figures 4,5,7,8 * * column 3, line 28 - line 68 * * column 5, line 34 - column 7, line 17 * * claim 18 * * column 8, line 12 - column 9, line 62 * ---	1,2,4,5, 17-19,36	
A	US-A-5 148 272 (ACAMPORA ALFONSE A ET AL) 15 September 1992 * abstract; figures 1,3,5 * * column 3, line 14 - column 4, line 59 * * column 6, line 58 - column 7, line 14 * * column 9, line 5 - line 40 * --- -/--	25	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 July 1996	Examiner Schiwy-Rausch, G
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- &amp; : member of the same patent family, corresponding document</p>			

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Application Number  
EP 94 10 3038

DOCUMENTS CONSIDERED TO BE RELEVANT				
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)	
A	EP-A-0 517 141 (TOKYO SHIBAURA ELECTRIC CO ;TOSHIBA AVE KK (JP)) 9 December 1992 * figures 11A-11C, 24 * * claims 1-4 * * page 13, line 45 - line 55 * * page 6, line 8 - line 57 * ---	25-29, 33-35		
A	EP-A-0 158 166 (SANYO ELECTRIC CO) 16 October 1985 * claims 1,2; figure 5 * * page 14, line 6 - page 15, line 13 * * page 10, line 23 - page 13, line 2 * * page 7, line 4 - line 21 * ---	36		
A	EP-A-0 355 721 (CANON KK) 28 February 1990 * figures 6,8,10,12,13 * * column 13, line 30 - column 15, line 27 * * column 9, line 17 - column 10, line 3 * * column 3, line 3 - line 54 * ---	36-40		
A	US-A-4 760 474 (TAKIMOTO HIROYUKI) 26 July 1988 * column 3, line 19 - column 6, line 24 * * abstract; figures 1-3 * ---	36		TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 011, no. 389 (P-648), 19 December 1987 & JP-A-62 154203 (MATSUSHITA ELECTRIC IND CO LTD), 9 July 1987, * abstract * ---			
A	US-A-4 731 659 (KANI TETSUO) 15 March 1988 ---			
The present search report has been drawn up for all claims				
Place of search THE HAGUE		Date of completion of the search 11 July 1996	Examiner Schiwy-Rausch, G	
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... &amp; : member of the same patent family, corresponding document</p>				

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# EUROPEAN SEARCH REPORT

Application Number  
EP 94 10 3038

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
E	EP-A-0 596 826 (GOLD STAR C0) 11 May 1994  * column 2, line 32 - line 56 * * column 3, line 41 - line 57 * * figures 9-10D * -----	1-5, 12-17	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 July 1996	Examiner Schiwy-Rausch, G
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document			

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EP 94 10 3038

### CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid.  
namely claims:
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

### LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions.  
namely:

-see sheet B-

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid.  
namely claims:
- ☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims.  
namely claims:



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EP 94 10 3038 -B-

**LACK OF UNITY OF INVENTION**

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims 1-24: Apparatus for recording and reproducing data on first and second portions using three or more speeds
2. Claims 25-35: Apparatus for recording and reproducing video data with variable length coding
3. Claims 36-40: Apparatus for recording and reproducing data using sync blocks and pilot signals for recording



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